NASA SP–7037 (265)
May 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
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AERONAUTICAL ENGINEERING

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National Aeronautics and Space Administration
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INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 554 reports, journal articles, and other documents originally announced in April 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-15123 — N91-16987
IAA (A-10000 Series)	A91-20489 — A91-24168

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1991 will be published in early 1992.

Information on availability of documents listed, addresses of organizations, and NTIS price schedules are located at the back of this issue.

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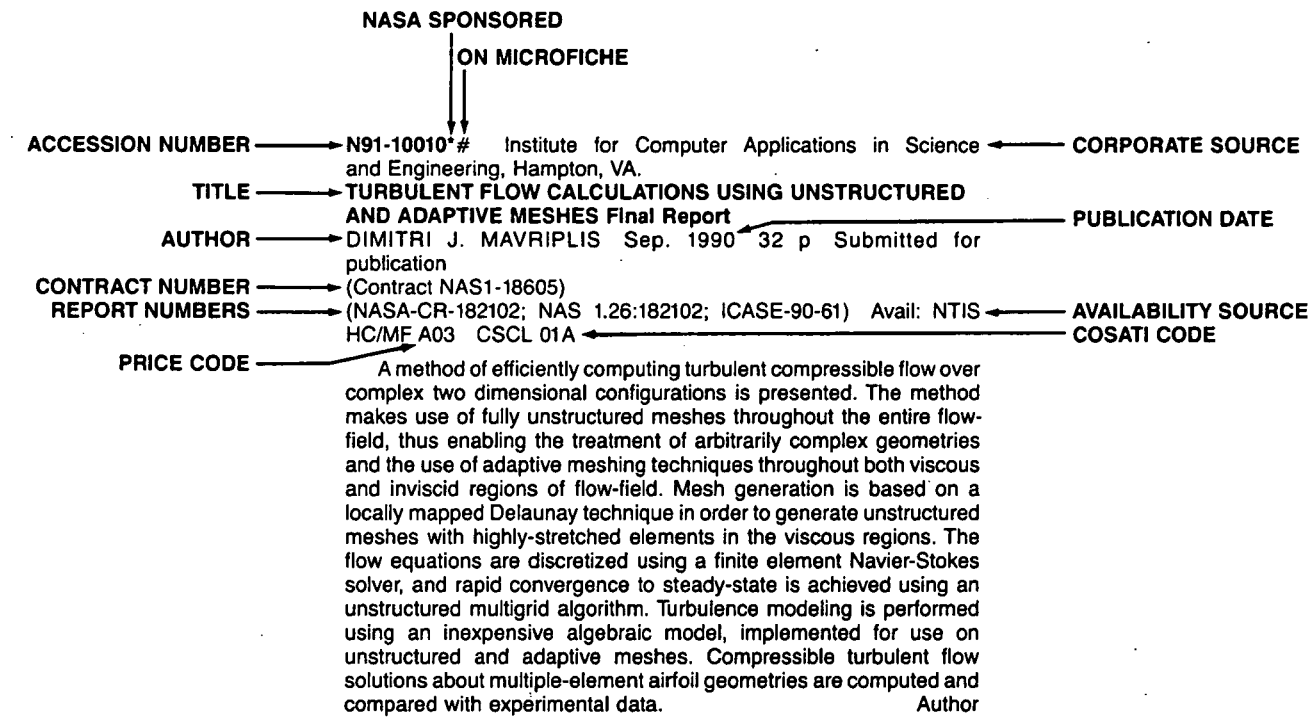
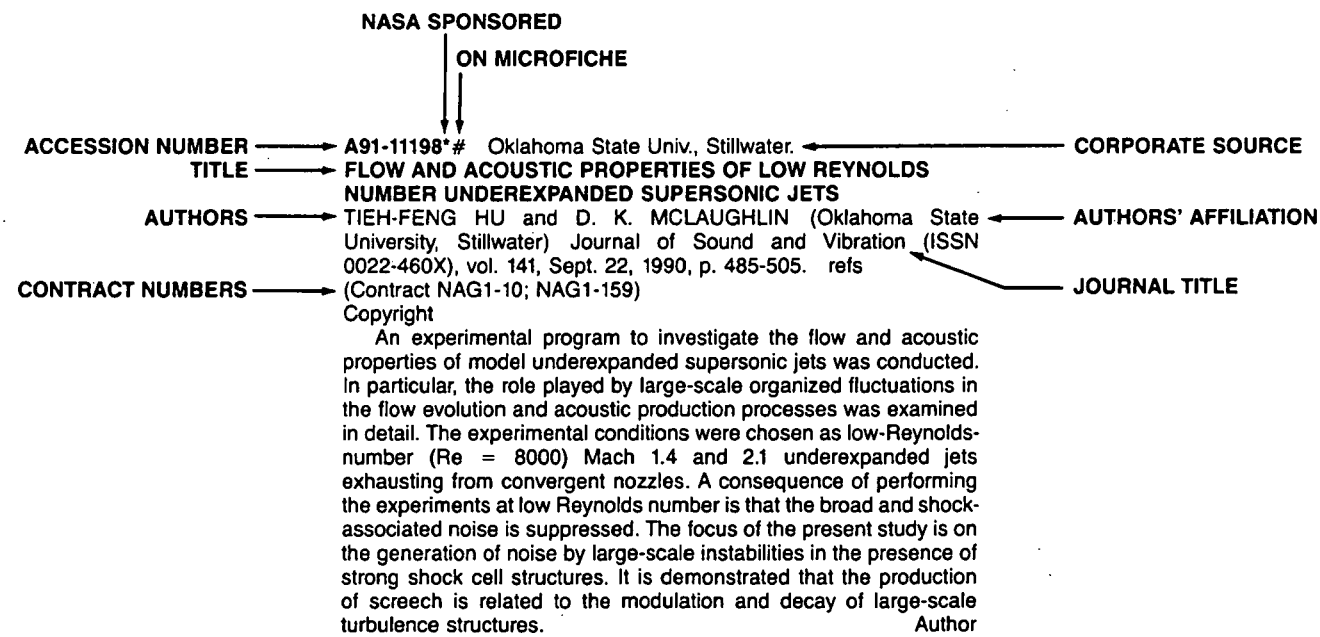
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 265)

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01

AERONAUTICS (GENERAL)

A91-20784
COMPOSITE PATCH REINFORCEMENT OF CRACKED AIRCRAFT UPPER LONGERON - ANALYSIS AND SPECIMEN SIMULATION
C. L. ONG, R. C. CHU, T. C. KO, and S. B. SHEN (Aero Industrial Development Center, Aeronautical Research Laboratory, Taichung, Republic of China) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 14, Sept. 1990, p. 13-26. refs
Copyright

Methods by means of which composite patch repairs can restore the structural integrity of cracked components are illustrated. The requisite patch-bonding strengths are reachable with a phosphoric-acid anodize (PAA) surface treatment of Al alloy components prior to application of the AV138/HV998 adhesive; a dismantling of the component from its assembled position for immersion in the PAA tank was not required. Boron/epoxy and carbon/epoxy patches were applied at room temperature to 7075-T6511 cracked specimens and tested under fatigue simulating the load spectrum of a fuselage longeron. The repair yielded a substantial improvement in fatigue life. O.C.

A91-20997
DOD NONLETHAL UNMANNED AERIAL VEHICLES JOINT PROJECT TEST AND EVALUATION
LAWRENCE G. KARCH and H. CLAUDE JONES (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 4.4-1 to 4.4-7.
Copyright

Unmanned aerial vehicle (UAV) systems are militarily useful alternatives to manned vehicles combining mission effectiveness with low risk to personnel and lower costs. Nonlethal UAV systems are capable of the following real-time and near-real-time operations: target acquisition, reconnaisance and surveillance; target spotting and designation; command and control/communications and data relay; nuclear, biological and chemical detection; meteorological data collection; and deception and disruption. Nonlethal UAV systems generally contain the following subsystems: the air vehicle, data links, mission payloads, mission planning and control, launch and recovery, and support subsystems. Operational requirements and environments are discussed, and categories of nonlethal UAVs, including short range, medium range, close range, and endurance types, are described. R.E.P.

A91-21001
THE EQUIPMENT OF A RESEARCH AIRCRAFT WITH EMPHASIS ON METEOROLOGICAL EXPERIMENTS
RUDOLF HANKERS (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 6.3-1 to 6.3-7. refs
Copyright

The research aircraft Dornier 128-6 of the Technical University of Braunschweig is equipped with a variety of different sensors. It is widely used for airborne investigations e.g. identification of the aerodynamic parameters of the aircraft, measurement of air pollution and meteorological measurements. Due to the powerful on-board measuring and computer system the aircraft is well suited for this wide range of research projects. This system is concepted mainly for on-line data acquisition and computation. The possibility of monitoring flight test processes allows the active participation of the test engineer which is very important especially for meteorological experiments. Author

A91-21106
DESIGNING AND MANUFACTURING THE F-111 ADVANCED COMPOSITE FORWARD VENTAL STRAKE
ALLEGRA D. HAKIM and DENNIS M. CONBOY (USAF, Advanced Composites Program Office, McClellan AFB, CA) Society of Manufacturing Engineers, Conference on Composites in Manufacturing 9, San Diego, CA, Jan. 15-18, 1990. 14 p.
(SME PAPER EM90-105) Copyright

The paper describes an F-111 forward ventral strake composed of an aramid/epoxy and graphite/epoxy hybrid skin over a nonmetallic core. This strake is replacing the original design consisting of two skins of fiberglass preimpregnated cloth bonded over a wedge of fiberglass-reinforced phenolic honeycomb core. A preliminary redesign involved skins fabricated predominantly of Kevlar/epoxy fabric and the final redesign utilizing a tapered hybrid skin of Kevlar prepreg fabric and graphite/epoxy tape over a glass/phenolic core extending from the baseplate to the edge of the strake are described. Static and flight tests are outlined, manufacturing considerations including a three-dimensional surfaced model, tooling, and core creation are discussed, and life-cycle cost savings are calculated. V.T.

A91-21107
ADVANCED COMPOSITES F-4 RUDDER
DENNIS TANG (USAF, Advanced Composites Program Office, McClellan AFB, CA) Society of Manufacturing Engineers, Conference on Composites in Manufacturing 9, San Diego, CA, Jan. 15-18, 1990. 15 p.
(SME PAPER EM90-106) Copyright

An effort to redesign the F-4 rudder in order to reduce the high failure rate of the aft honeycomb trailing-edge section is addressed, and emphasis is placed on maintaining consistent form, fit, and function at minimum cost. Design and manufacturing considerations such as bending stiffness, core selection, laminate instability, and damage tolerance are discussed, and core fabrication, tooling, and full-scale static tests are described. The choice of skin material is narrowed to unidirectional graphite/epoxy prepreg, while the core is made of polymethacrylimide foam fabricated with the help of a contoured tool designed on a CAD/CAM system using a geometrical model of the rudder core. V.T.

A91-21201
MAINTENANCE OF MODERN AVIONICS SYSTEMS; PROCEEDINGS OF THE CONFERENCE, HEATHROW, ENGLAND, MAY 9, 1989
London, Royal Aeronautical Society, 1989, 78 p. For individual items see A91-21202 to A91-21206.
Copyright
Attention is given to such topics as the limitations of BITE, the ACARS system, and the Aircraft Avionic Interconnection System. The problems and solutions for testing air data systems on aircraft, and the development of onboard maintenance systems on Boeing aircraft are also considered. R.E.P.

A91-21202
LIMITATIONS OF BITE
A. VAUGHAN and P. D. HALL (Monarch Aircraft Engineering, Ltd., Luton, England) IN: Maintenance of modern avionics systems; Proceedings of the Conference, Heathrow, England, May 9, 1989. *London, Royal Aeronautical Society, 1989, p. 1.1-1.22.*
Copyright
The introduction and development of built-in test equipment (BITE) on today's transport aircraft have had a significant impact on maintenance procedures and traditional troubleshooting techniques. The flight management system (FMS) BITE is designed to be operated within the principle of 'on condition' maintenance. A flight-crew-reported defect is utilized to determine which of the FMS subsystems is involved, and by using the BITE, isolate the *faulty line replaceable unit. Finally, manufacturers must be able to* react more quickly to in-service problems and produce effective improvements in a prompt manner to maintain confidence in the integrity of the system. R.E.P.

A91-21206
DEVELOPMENT OF ONBOARD MAINTENANCE SYSTEMS ON BOEING AIRPLANES
ANTHONY J. MARTIN (Boeing Commercial Airplanes, Seattle, WA) IN: Maintenance of modern avionics systems; Proceedings of the Conference, Heathrow, England, May 9, 1989. London, Royal Aeronautical Society, 1989, p. 5.1-5.15.
Copyright
A review is presented of onboard maintenance development from the evolution of maintenance functions or built-in test equipment (BITE) in individual units through small-scale integration around autopilot and flight management systems to central integrated maintenence computer systems. Various issues concerning onboard maintenance systems are discussed including aviation industry standards, the reliability and maintainability of digital avionics systems, the measurement of reliability in the aircraft environment, and airline line maintenance practice. A new 747-400 Central Maintenance Computer (CMC) that integrates all 70 electronic systems of the aircraft is described. It is concluded that maintenance functions must be designed into systems from the onset of the design process, and industry standards for BITE are essential. R.E.P.

A91-21218
WINGS FOR THE 21ST CENTURY
JAMES BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 11, Jan. 1991, p. 9-12.
Copyright
Researchers and aeronautical engineers have analyzed the aircraft wing design process with an eye toward increasing strength, fatigue life, and reliability, while at the same time reducing weight and cost. The underutilized structural capability of the wing (overcompensating for fatigue, panel instability, and lightning strike considerations) equates to added unnecessary weight. One proposed wing design has the upper surface optimized for all possible loading conditions along the entire wing span. Thus, the wing's upper surface would incorporate three separate designs, each considering the fact that the compression loads increase from wing tip to wing root. In this optimized wing's upper surface midsection, an isogrid/waffle design could be utilized. With this isogrid/waffle design, parts count and the number of fastener holes can be significantly reduced. New material applications and machining techniques are also discussed. R.E.P.

A91-21324
1989 SPRING CONVENTION - FLIGHT SIMULATION: ASSESSING THE BENEFITS AND ECONOMICS, LONDON, ENGLAND, MAY 17, 18, 1989, PROCEEDINGS
Convention sponsored by the Royal Aeronautical Society. London, Royal Aeronautical Society, 1989, 226 p. No individual items are abstracted in this volume.
Copyright
The use of flight simulators in aircrew training and research is discussed, considering both technological and economic aspects. Topics addressed include advanced simulators for ab initio pilot training, the economic advantages of investing in state-of-the-art flight-simulation equipment, the use of full flight simulators by a commercial airline, cost-effective distributed processing for simulators, and the evolution and economics of software engineering for flight simulation. Consideration is given to cost-performance tradeoffs in visual simulation, a data-base approach to cost management for a versatile research flight simulator, the future of flight simulation, and an FAA perspective on increasing the benefits of flight simulation. T.K.

A91-22102
PAINTING TECHNOLOGY FOR CIVIL AIRCRAFT AND HELICOPTERS (2ND REVISED AND ENLARGED EDITION) [TEKHNOLOGIIA OKRASKI SAMOLETOV I VERTOLETOV GRAZHDANSKOI AVIATSII /2ND REVISED AND ENLARGED EDITION/]
IL'IA I. DENKER and VIKTOR N. VLADIMIRSKII Moscow, Izdatel'stvo Mashinostroenie, 1988, 128 p. In Russian. refs
Copyright
The materials, techniques, and tools used for the corrosion protection and painting of the external and internal surfaces of commercial airplanes and helicopters are discussed. In particular, general data are presented on the corrosion of metals and alloys; principal structural materials used in aircraft building; types of paints, primers, and thinners; surface preparation techniques; and different methods of applying paints. The discussion also covers specific paint systems for aluminum, magnesium, and steel surfaces, interior paints, paints for contacts and radio and electronic components, engine paints, paints for propellers, and repair of painted surfaces. Finally, some safety and fire prevention measures are discussed. V.L.

A91-22104
ASSEMBLY OF AIRCRAFT COMPONENTS [SBORKA AGREGATOV SAMOLETA]
VASILII V. BOITSOV, SHARAFUTDIN F. GANIKHANOV, and VLADIMIR N. KRYSIN Moscow, Izdatel'stvo Mashinostroenie, 1988, 152 p. In Russian. refs
Copyright
The principles and methods of computer-aided spacecraft assembly are reviewed. The types of assembly operations, principal assembly techniques, and the efficiency of assembly processes are examined. Attention is then given to the analysis of the structure of assembly processes and methods for optimizing assembly work. The discussion also covers assembly tools and equipment, typical assembly schemes for the principal aircraft components, and systems for the design and manufacture of assembly equipment. V.L.

A91-23546
MAINTENANCE STANDARDS
A. C. D. CUMMING (British Airways, PLC, Hounslow, England) (European Aerospace Conference on Civil Aviation Operations - Problems, Solutions and Actions, 3rd, London, England, May 22-24, 1990) Aeronautical Journal (ISSN 0001-9240), vol. 94, Dec. 1990, p. 329-334.
Copyright
This paper discusses why maintenance standards are the most

important technical factor within the control of the operator, and how this control is exercised. High maintenance standards have a direct beneficial effect on safety. Details are provided for British Airway's maintenance control program and quality monitoring, incident investigation, and involvement of senior management are discussed. R.E.P.

A91-23547
ADVANCED TECHNOLOGY - CONSTANT CHALLENGE AND EVOLUTIONARY PROCESS
D. SCHMITT (Airbus Industrie, Toulouse, France) (European Aerospace Conference on Civil Aviation Operations - Problems, Solutions and Actions, 3rd, London, England, May 22-24, 1990) Aeronautical Journal (ISSN 0001-9240), vol. 94, Dec. 1990, p. 335-340.
Copyright

An overview is presented of the main improvement potentials in the European civil aircraft industries. Consideration is given to such areas of development as new powerplant concepts, aerodynamics, new structures and materials, aircraft systems, and production technology. In assessing technology benefits, all of the aforementioned items may count for a theoretical improvement potential of a further 30 to 35 percent in terms of specific energy saving per aircraft seat mile; however, this assumes a major breakthrough in laminarization, which counts for nearly half of the potential improvement. The development of hybrids, that allow weight reductions of up to 40 percent in tension-loaded, fatigue critical structural components, is also promising. R.E.P.

N91-15124*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DYNAMIC ANALYSIS OF ROTOR BLADE UNDERGOING ROTOR POWER SHUTDOWN
KHANH QUOC NGUYEN Dec. 1990 27 p
(NASA-TM-102865; A-90284; NAS 1.15:102865) Avail: NTIS HC/MF A03 CSCL 01B

A rigid flap-lag blade analysis was developed to simulate a rotor in a wind tunnel undergoing an emergency power shutdown. Results show that for a rotor at a nonzero shaft tilt angle undergoing an emergency power shutdown, the oscillatory lag response is divergent. The mean lag response is large when tested at high collective pitch angles. Reducing the collective pitch during the emergency shutdown reduces the steady lag response. Increasing the rotor shaft tilt angle increases the oscillatory lag response component. The blade lag response obtained by incorporating a nonlinear lag damper model indicates that in this case the equivalent linear viscous damping is lower than originally expected. Simulation results indicate that large oscillatory lag motions can be suppressed if the rotor shaft is returned to the fully vertical position during the emergency power shutdown. Author

N91-15977# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Forschungsbereich Stroemungsmechanik.
DOCUMENTS ON THE HISTORY OF THE AERODYNAMIC RESEARCH ESTABLISHMENT AT GOETTINGEN, 1907 - 1925
JULIUS C. ROTTA Apr. 1990 174 p In GERMAN; ENGLISH summary
(DLR-MITT-90-05; ISSN-0176-7739; ETN-91-98261) Avail: NTIS HC/MF A08; DLR, VB-PL-DO, Postfach 90 60 58, Cologne, Fed. Republic of Germany, HC 27 DM

A supplement to a history of the Aerodynamic Research Establishment is presented. Subjects covered are the model research facilities; first interests in aeronautical engineering; the project of an institute for aerodynamics and hydrodynamics; permission given by military authorities during the First World War for the creation of an aerodynamic research institute; construction of the model research center for aerodynamics; and the research equipment used in the institute after the First World War. ESA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A91-20615
AIRFRAME-ENGINE INTEGRATION - TASK FOR FUTURE COMMERCIAL AIRCRAFT EVOLUTION [ZELLE-TRIEBWERKS-INTEGRATION - AUFGABE ZUKUENFTIGER VERKEHRSFLUGZEUGENTWICKLUNGEN]
HEINZ HOHEISEL (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 34-39. In German.
Copyright

The numerical treatment of the problem of airframe-engine integration is discussed. The experimental determination of interference effects is addressed. The significance of the results for future commercial aircraft evolution is considered. C.D.

A91-20745#
AERODYNAMIC DESIGN FOR SUPERSONIC NOZZLES OF ARBITRARY CROSS SECTION
A. HADDAD and J. B. MOSS (Cranfield Institute of Technology, Bedford, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 740-746. refs
Copyright

A comparatively simple method for obtaining wall contours of supersonic nozzles of arbitrary exit cross sections from readily determined axisymmetric flows is presented. An initial axisymmetric flowfield is calculated using the method of characteristics in two dimensions from whch the desired three-dimensional shape may be generated by specifying the appropriate cross section at the streamwise station giving the required overall nozzle length and exit Mach number. The describing points on the perimeter of this section are traced along corresponding streamlines back to the throat. The stream sheets formed by these streamlines then define the new nozzle contour. Elliptical and two-dimensional wedge-shaped nozzles are designed using this approach, and comparisons are reported between detailed finite-difference flowfield predictions and experimental measurement. Author

A91-20748#
NUMERICAL INVESTIGATION OF HOT STREAKS IN TURBINES
BJORN KROUTHEN and MICHAEL B. GILES (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 769-776. Previously cited in issue 04, p. 462, Accession no. A89-16478. refs
Copyright

A91-20750#
EXPERIMENTAL MEASUREMENTS OF THE FLOW IN A SCRAMJET INLET AT MACH 4
WILLIAM J. YANTA, ARNOLD S. COLLIER, W. CHARLES SPRING, III, CHRISTOPHER F. BOYD (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD), and J. CRAIG MCARTHUR Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 784-790. Research supported by the U.S. Navy. Previously cited in issue 07, p. 930, Accession no. A88-22198. refs

A91-20933#
COMPUTATION OF UNSTEADY VISCOUS FLOWS AROUND WING PROFILES [BERECHNUNG INSTATIONAERER VISKOSER STROEMUNGEN UM TRAGFLUEGELPROFILE]
K. DORTMANN Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen (ISSN 0172-3898), no. 30, 1990, p. 34-44. In German. refs

Central-difference schemes for the numerical simulation of unsteady viscous flows on wing profiles are evaluated by means of test computations. The mathematical bases of the Navier-Stokes

solvers employed are outlined, and results are presented graphically for (1) a NACA 0012 profile at angle of attack 20 deg, Reynolds number 20,000, and freestream Mach number 0.3 and (2) a NACA 4412 profile at zero angle of attack and Reynolds number 5000-20,000. Generally good accuracy is obtained using the cell-vertex multigrid approach of Hall (1986) with artificial damping terms. It is found, however, that artificial dissipation can significantly degrade the accuracy of the solution in case (1) unless the damping coefficients are minimized. In case (2), where there is early separation and a vortex street forms in the wake, a grid refinement to 512 x 64 points is required to give wake Strouhal numbers within 6 percent of experimentally measured values. T.K.

A91-20934#
EXPERIMENTAL INVESTIGATION OF THE TRANSONIC FLOW ON A SUPERCRITICAL WING PROFILE [EXPERIMENTELLE UNTERSUCHUNG DER SCHALLNAHEN UMSTROEMUNG EINES SUPERKRITISCHEN TRAGFLUEGELPROFILS]
H.-J. ROMBERG Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen (ISSN 0172-3898), no. 30, 1990, p. 45-53. In German. refs

The steady flow on CAST7 supercritical wing profiles of chord length 150 and 200 mm is investigated experimentally at Mach numbers between 0.61 and 0.79 in the adaptive-wall test section of the large transonic/supersonic wind tunnel of the Aerodynamisches Institut in Aachen. The experimental setup and measurement procedures are described, and the results are presented in graphs and photographs and characterized in detail. The pressure distributions obtained in the adaptive tunnel are found to be in good agreement with published data from larger facilities, but at maximum lift there were discrepancies with respect to the lift coefficient, the size of the supersonic region, and the trailing-edge pressure. Shock oscillations are observed at Mach numbers 0.70-0.78 and angles of attack 3-5 deg and tentatively attributed to the effects of vortex formation in the wake. T.K.

A91-20935#
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF A VORTEX STREET IN THE WAKE OF A FLAT PLATE [EXPERIMENTELLE UND THEORETISCHE UNTERSUCHUNG EINER WIRBELSTRASSE IM NACHLAUF EINER EBENEN PLATTE]
W. ALTHAUS Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen (ISSN 0172-3898), no. 30, 1990, p. 54-59. In German. refs

Results are reported from wind-tunnel experiments on flat plates to which strips of smooth paper or sandpaper (mean roughness 0.43 or 0.18 mm), extending to leave an uncovered band (UB) of a few mm at the trailing edge, are attached to induce vortex formation (VF). Holographic interferometry and two-component LDA measurements obtained at Mach 2.2 in the 15 x 15-cm wind tunnel of the Aerodynamisches Institut in Aachen are presented in graphs and discussed in detail. With the smooth paper, the wake flow is fully turbulent, whereas with sandpaper there is VF slightly behind the trailing edge; VF reaches a maximum when the UB width is 5 mm, and the location of visible VF depends on the roughness of the paper and the UB width, in good agreement with the theoretical model of Hannemann (1988). T.K.

A91-20936#
CALCULATION OF THREE-DIMENSIONAL COMPRESSIBLE BOUNDARY LAYERS ON SLENDER BODIES [BERECHNUNG DREIDIMENSIONALER KOMPRESSIBLER GRENZSCHICHTEN AN SPITZEN KOERPERN]
V. N. VETLUTSKII (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) and E. KRAUSE Rheinisch-Westfaelische Technische Hochschule, Aerodynamisches Institut, Abhandlungen (ISSN 0172-3898), no. 30, 1990, p. 60-63. In German. refs

A numerical technique for the characterization of three-dimensional compressible supersonic boundary-layer flows on slender bodies is described. The forebody (assumed to be conical) is analyzed using the similarity method of Vetlutsky and Ganimedov (1982), and the general solution is obtained using the difference method of Vetlutsky (1981). The method is applied to smooth bodies with double-ellipse and ogival body cross sections and circular-cone nose sections at freestream Mach numbers 2-4 and angles of attack 4.2-10 deg, incorporating several different mixing-path models for the turbulent boundary layers. Results are expressed in terms of Stanton-number distribution, velocity and temperature profiles, and drag coefficients and compared with published experimental data. Good general agreement is demonstrated; for the turbulent boundary layers, best agreement is obtained using the Baldwin-Lomax (1978) model with C(cp) varied from 3.6 to 1.6. T.K.

A91-21057#
TURBULENT SHEAR FLOW OVER SURFACE MOUNTED OBSTACLES
W. H. SCHOFIELD (Defence Science and Technology Organization, Aeronautical Research Laboratory, Melbourne, Australia) and E. LOGAN (Arizona State University, Tempe) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 112, Dec. 1990, p. 376-385. refs
Copyright

The mean flow field surrounding obstacles attached to a wall under a turbulent boundary layer is analyzed. The analysis concentrates on how major features of the flow are influenced by model geometry and the incident shear flow. Experimental data are analyzed in terms of nondimensionalized variables chosen on the basis that their effect on major flow features can be simply appreciated. The data are restricted to high Reynolds number shear layers thicker than the attached obstacle. The work shows that data from a wide range of flows can be collapsed if appropriate nondimensional scales are used. Author

A91-21063#
INTERFERENCE DRAG OF A TURBULENT JUNCTION VORTEX
F. J. PIERCE (Virginia Polytechnic Institute and State University, Blacksburg) and S. K. NATH (Du Pont de Nemours and Co., Richmond, VA) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 112, Dec. 1990, p. 441-446. refs
(ASME PAPER 90-WA/FE-2) Copyright

The interference drag identified with the junction of a streamlined cylindrical body and a flat plate was investigated. The junction drag was calculated from a set of detailed, self consistent, high quality data using a control volume approach. The drag for the isolated flat plate and streamlined cylinder making up the junction was calculated using boundary-layer solvers together with surface pressure measurements. For the particular and relatively thick body under consideration, the results show a significant increase in drag due to the junction. These and other available results indicate that the interference drag has a systematic dependence on the thickness to chord ratio. The junction vortex wake increases the downstream flat plate drag significantly. Because of this effect, a unique value for the drag force, drag coefficient, or induced drag coefficient for a junction vortex flow would require that the geometry be specified in detail. The induced drag and the total pressure losses identified with the junction are also reported. Author

A91-21064*# Florida Atlantic Univ., Boca Raton.
NONIDEAL ISENTROPIC GAS FLOW THROUGH CONVERGING-DIVERGING NOZZLES
W. BOBER and W. L. CHOW (Florida Atlantic University, Boca Raton) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 112, Dec. 1990, p. 455-461. refs
(Contract NAS2-11555)
Copyright

A method for treating nonideal gas flows through converging-diverging nozzles is described. The method incorporates the Redlich-kwong equation of state. The Runge-Kutta method is used to obtain a solution. Numerical results were obtained for methane gas. Typical plots of pressure, temperature, and area ratios as functions of Mach number are given. From the

plots, it can be seen that there exists a range of reservoir conditions that require the gas to be treated as nonideal if an accurate solution is to be obtained. Author

A91-21065*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES SIMULATION OF TRANSONIC BLADE-VORTEX INTERACTIONS
N.-S. LIU (NASA, Lewis Research Center, Cleveland, OH; Scientific Research Associates, Glastonbury, CT), F. DAVOUDZADEH, W. R. BRILEY, and S. J. SHAMROTH (Scientific Research Associates, Inc., Glastonbury, CT) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 112, Dec. 1990, p. 501-509. refs
(Contract NAS2-12635)
Copyright

Transonic strong blade-vortex interaction is numerically analyzed by solving the unsteady two-dimensional Navier-Stokes equations using an iterative implicit second order scheme. The dominant processes during the interaction are the development of large transverse pressure gradients in the upper leading edge region and the development of disturbances at the root of the lower surface shock wave. As a result of this interaction, high pressure pulses are emitted from the leading edge, and acoustic waves are radiated from the lower surface in a region originally occupied by a supersonic pocket. In addition, severe load variations occur when the vortex is within one chord length of the blade. Author

A91-21066#
APPLICATION OF AN IMPLICIT RELAXATION METHOD SOLVING THE EULER EQUATIONS FOR TIME-ACCURATE UNSTEADY PROBLEMS
A. BRENNEIS and A. EBERLE (MBB GmbH, Munich, Federal Republic of Germany) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 112, Dec. 1990, p. 510-520. refs
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A numerical procedure is presented for computing time-accurate solutions of flows about two and three-dimensional configurations using the Euler equations in conservative form. A nonlinear Newton method is applied to solve the unfactored implicit equations. Relaxation is performed with a point Gauss-Seidel algorithm ensuring a high degree of vectorization by employing the so-called checkboard scheme. The fundamental feature of the Euler solver is a characteristic variable splitting scheme (Godunov-type averaging procedure, linear locally one-dimensional Riemann solver) based on an eigenvalue analysis for the calculation of the fluxes. The true Jacobians of the fluxes on the right-hand side are used on the left-hand side of the first order in time-discretized Euler equations. A simple matrix conditioning needing only few operations is employed to evade singular behavior of the coefficient matrix. Numerical results are presented for transonic flows about harmonically pitching airfoils and wings. Comparisons with experiments show good agreement except in regions where viscous effects are evident. Author

A91-21176
INTERNATIONAL CONFERENCE ON HYPERSONIC AERODYNAMICS, VICTORIA UNIVERSITY OF MANCHESTER, ENGLAND, SEPT. 4-6, 1989, PROCEEDINGS
London, Royal Aeronautical Society, 1989, 385 p. For individual items see A91-21177 to A91-21197.
Copyright

Topics presented include an interim technology concept for an innovative fully reusable launch vehicle, some ground facilities for hypersonic simulation, a review of a code development and calibration program in support of the Aeroassist Flight Experiment, and hypersonic flow calculations using locally body-fitting and overlapping grids. Also presented are three-dimensional simulations of hypersonic flows, the solution of the Euler equations for a dissociating gas by the finite element method, the computation of high speed compressible viscous flows by total variation diminishing (TVD) schemes, and nonadiabatic hypersonic boundary layers with nonsimilar pressure gradients. Also addressed are the modeling and calculation of laminar hypersonic boundary layer flows, the dynamic effects of hypersonic separated flow, and boundary layer transition and heat transfer on slender delta wings. R.E.P.

A91-21180
THE AERODYNAMIC CHARACTERISTICS OF POWER-LAW BODIES IN CONTINUUM AND TRANSITIONAL HYPERSONIC FLOW
M. F. WESTBY and J. D. REGAN (Royal Aerospace Establishment, Weapon Systems Aerodynamics Div., Farnborough, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 4.1-4.18. Previously announced in STAR as N90-22537. refs
Copyright

The experimental studies presented were carried out to determine the aerodynamic characteristics of a series of power-law bodies of constant fineness ratio over a Reynolds number range covering both continuum and transitional rarefied flow. The tests were performed at Mach numbers of 10 in the low density tunnel and 12.8 in the gun tunnel at angles of incidence up to 30 degrees. Author

A91-21183
HYPERSONIC FLOW CALCULATIONS USING LOCALLY BODY-FITTING AND OVERLAPPING GRIDS
I. M. HALL (Manchester, Victoria University, England) and S. SHAHPAR IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 9.1-9.14. refs
Copyright

A calculation procedure utilizing overlapping grids is applied to the solutions of two-body problems, and its usefulness in the discretization of geometrically complicated flow regions is demonstrated. The extent of the overlap region between the different grids and the relative size of each subdomain are the principal factors affecting the accuracy and convergence speed of the scheme. Numerical results show that increasing the extent of the overlap region decreases the quantity of iterations for convergence. The time accuracy of the method is demonstrated by the solution of the swept cylinder problem where the general characteristics of a hypersonic flow (freestream M = 7.1) around the swept-cylinder are successfully simulated. R.E.P.

A91-21184
THREE-DIMENSIONAL SIMULATIONS OF HYPERSONIC FLOWS
M. PFITZNER, W. SCHROEDER, S. MENNE, and C. WEILAND (MBB GmbH, Munich, Federal Republic of Germany) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 10.1-10.15. refs
Copyright

Flow codes for the simulation of three-dimensional hypersonic flows are presented in this paper. The equilibrium real gas flow about a reentry configuration and about a two-stage reusable launch vehicle is simulated by a code based on the quasi-conservative form of the Euler equations in conjunction with a bow shock fitting algorithm and a Runge-Kutta time stepping scheme. Imbedded shocks are captured. Flows about more complicated geometries containing very strong shocks are simulated using a code based on a symmetric TVD discretization and explicit and implicit time integration. Author

A91-21188* Old Dominion Univ., Norfolk, VA.
2-D AND 3-D MIXING FLOW ANALYSES OF A SCRAMJET-AFTERBODY CONFIGURATION
OKTAY BAYSAL, MOHAMED E. ELESHAKY, and WALTER C. ENGELUND (Old Dominion University, Norfolk, VA) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal

Aeronautical Society, 1989, p. 14.1-14.16. refs
(Contract NAG1-811)
Copyright

A cold simulant gas study of propulsion/airframe integration for a hypersonic vehicle powered by a scramjet engine is presented. The specific heat ratio of the hot exhaust gases are matched by utilizing a cold mixture of argon and Freon-12. Solutions are obtained for a hypersonic corner flow and a supersonic rectangular flow in order to provide the upstream boundary conditions. The computational test examples also provide a comparison of this flow with that of air as the expanding supersonic jet, where the specific heats are assumed to be constant. It is shown that the three-dimensional computational fluid capabilities developed for these types of flow may be utilized to augment the conventional wind tunnel studies of scramjet afterbody flows using cold simulant exhaust gases, which in turn can help in the design of a scramjet internal-external nozzle. R.E.P.

A91-21189* University of Southern California, Los Angeles.
ON HYPERSONIC SHOCK LAYER AND ITS EXTENSION BEYOND THE NAVIER-STOKES LEVEL
H. K. CHENG (Southern California, University, Los Angeles, CA) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 15.1-15.16. refs
(Contract AF-AFOSR-88-0146; NAGW-1061)
Copyright

An extension of the continuum model beyond the Navier-Stokes (NS) level and related issues on problem formulation are examined for a hypersonic shock layer on the basis of Grad's thirteen-moment equations for a Maxwell gas. The 13-moment system, simplified consistently with a fully viscous version of the thin shock-layer approximation, permits correlation with the corresponding NS-based solution. With the exception of pressure and density, several flow properties including normal stress, shear stress and normal heat flux along a streamline are unaffected by translational nonequilibrium and are therefore predicted correctly by the NS solution to the leading order, even in a domain far from translational equilibrium where molecular-transport processes rank equally with the convection. Author

A91-21190
MODELLIZATION AND CALCULATION OF LAMINAR HYPERSONIC BOUNDARY LAYER FLOWS
M. L. SAWLEY, J. B. VOS, and S. WUETHRICH (Lausanne, Ecole Polytechnique Federale, Switzerland) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 18.1-18.16. Research supported by AMDBA and Commission pour l'Encouragement de la Recherche Scientifique of Switzerland. refs
Copyright

A study of the physical modelization and calculation of hypersonic boundary layer flow relevant to high temperature re-entry conditions is presented. A model for air comprised of a mixture of five chemical species is considered. The transport coefficients are determined using a simplified formulation of kinetic theory. Special consideration is given to the effects of equilibrium and non-equilibrium chemistry and radiative transfer. Solutions for the laminar, compressible, boundary layer flow over two-dimensional planar and axisymmetric bodies are presented. Author

A91-21191
HYPERSONIC VISCOUS INTERACTION REVISITED
JOHN L. STOLLERY and UWE BEYER (Cranfield Institute of Technology, Bedford, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 20.1-20.13. refs
Copyright

A previous theoretical analysis of hypersonic viscous interaction on flat and curved surfaces is extended to the case of a flat plate at incidence with a deflected trailing edge flap. The incidence range covered is 0 to 40 degrees with flap deflections of between 0 and 30 degrees. By combining simple rules for boundary layer growth, pressure distribution, and the effective shape of the body, the flowfield can be solved to give the pressure and heat transfer rate distributions together with the development of the displacement thickness. Sample calculations have been made for a Mach number of 25 at a freestream Reynolds number (based on distance to the hinge line) of 100,000. The results show how viscous interaction significantly modifies the loads on the flap and reduces control effectiveness. Author

A91-21192
DYNAMIC EFFECTS OF HYPERSONIC SEPARATED FLOW
T. P. ROBERTS and R. A. EAST (Southampton, University, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 21.1-21.16. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

Results are presented of a study into the static and dynamic behavior of the hypersonic laminar and transitional separated flows generated over a flat plate-rearward flap configuration with special emphasis on the dynamic aspects. For the dynamic tests the motion of the flap consisted in rapid deployment from 0 to 40 degrees, followed by rapid reversal. This study has involved an experimental program in which many static pressure measurements and flow visualization experiments have been made for both the fixed flap and rapidly moving flap examples. A lag of up to about 1.3 degrees is found to occur between the flap angles for the fixed flap case and moving flap case, for a flap angular velocity of 50 rad/s, at which a given sized separation region is obtained. Consideration is also given to the evolution of the overall force and moment coefficients as the flap is rapidly deployed. R.E.P.

A91-21193
HYPERSONIC INTERACTIONS AND FLOW TRANSITION
A. F. KHORRAMI, A. J. NEISH, S. N. BROWN, and F. T. SMITH (University College, London, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 22.1-22.19. refs
Copyright

Some theoretical research studies into hypersonic flow in connection with boundary layers, shock layers, nozzle flows, interactions, and their instability and transition properties are presented. These studies are concerned with the continuum range, for high Mach numbers and Reynolds numbers. Consideration is given to steady, laminar, external two-dimensional flows in the hypersonic strong-interaction regime, and analytical features and finite-difference computations are described. Specific aspects are presented of the instability and transition of the hypersonic boundary layer and inviscid shock layer, including viscous and inviscid modes in the compressible boundary layer, inviscid modes in the shock layer, their interaction, and nonlinear effects such as vortex-wave interaction and finite-time break-up in the unsteady interactive boundary layer. R.E.P.

A91-21194
BOUNDARY-LAYER TRANSITION AND HEAT TRANSFER ON SLENDER DELTA WINGS
D. I. A. POLL (Manchester, Victoria University, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 23.1-23.19. refs
Copyright

The problem of boundary-layer transition via three different mechanisms - attachment-line contamination, cross-flow instability and tripping by isolated roughness elements - is considered in the context of flow over a slender delta wing. Existing knowledge of the transition mechanisms is summarized and estimates of the shape of the resulting transition fronts are made by linking the

phenomena to the topography of the flow at the edge of the boundary-layer. Simple relations are presented for the estimation of leading edge heating at small angles of incidence and wing center-line heating at large angles of incidence. Author

A91-21195* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PREDICTION OF TRANSITIONAL (LAMINAR-TURBULENT) HYPERSONIC FLOWS USING THE PARABOLIZED NAVIER-STOKES EQUATIONS
UPENDER K. KAUL (NASA, Ames Research Center, Moffett Field; Sterling Federal Systems, Inc., Palo Alto, CA) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 24.1-24.14. refs
Copyright

Hypersonic transitional flow predictions have been made using the parabolized Navier-Stokes equations with an algebraic transition/turbulence model by appropriately modulating the turbulent viscosity with the available intermittency functions for incompressible and compressible flows. A comparison between the predictions with and without a low Reynolds number correction has also been made. The predictions are compared with the available experimental data and with the theory over a range of Mach number. A simple Re(theta)/M(delta) criterion is shown to satisfactorily predict the meridional variation of the onset location of transition on a cone at a small angle of attack, whereas none of the correlations discussed can do that. Various available correlations are discussed vis-a-vis the predictions as to the locations of the onset and the end of transition. Author

A91-21198#
THEORETICAL ANALYSIS OF SUPERSONIC GAS-PARTICLE TWO-PHASE FLOW AND ITS APPLICATION TO RELATIVELY COMPLICATED FLOW FIELDS
NATSUO HATTA, HITOSHI FUJIMOTO, RYUJI ISHII (Kyoto University, Japan), and JUN-ICHI KOKADO (Niihama College of Technology, Japan) Kyoto University, Faculty of Engineering, Memoirs (ISSN 0023-6063), vol. 52, July 1990, p. 115-185. refs
(Contract MOESC-01550532)

Supersonic flows of a two-phase gas-particle mixture are considered in several complex situations. For a flow field in which the gas and particle phases interact, a model is constructed by incorporating the particle-trajectory method into the gas phase equations in the two-fluid model. Single-phase and two-phase flows of jets exhausted from a sonic nozzle are examined in detail. Single-phase results are compared with experimental results to see if the scheme is reliable. For two-phase results, particles with the same velocity and temperature as those of the gas are injected at the nozzle exit plane, and the effect of the presence of particles is studied by comparison with single-phase results. Next, results of numerical experiments in which jets impinge on a flat plane normal to the jet axis are considered for both the single-phase and two-phase cases. For a single-phase flow, periodic unstable oscillations are found to give fairly good agreement with experimental results. Finally, supersonic gas-particle two-phase flows around a sphere are simulated. The instability in particle motion near the stagnation region in the shock layer is discussed in detail. A.F.S.

A91-21242* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLOW STUDIES IN CLOSE-COUPLED VENTRAL NOZZLES FOR STOVL AIRCRAFT
JACK G. MCARDLE (NASA, Lewis Research Center, Cleveland, OH) and C. FREDERIC SMITH (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 22 p.
(SAE PAPER 901033) Copyright

Flow in a generic ventral nozzle system was studied experimentally and analytically with the PARC3D computational fluid dynamics program (a full Navier-Stokes equations solver) in order to evaluate the program's ability to predict system performance and internal flow patterns. A generic model of a tailpipe with a rectangular ventral nozzle, about one-third of full size, was tested with unheated air at steady-state pressure ratios up to 4.0. Measurements showed about 5.5 percent flow-turning loss and reasonable nozzle performance coefficients. The flow turned more than the designed 90 deg, causing an aftward axial component in the total thrust. Flow behavior into and through the ventral duct is discussed and illustrated with paint streak flow visualization photographs. PARC3D graphic images are shown for comparison with the experiment photographs. The program successfully predicted internal flow patterns; it also computed thrust and discharge coefficients within 1 percent of measured values. Author

A91-21257
TURBULENCE MODELING FOR COMPLEX GROUND EFFECTS FLOWS
ROBERT E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 13 p. Research supported by DARPA and USAF. refs
(SAE PAPER 901062) Copyright

The turbulent impinging jet flows associated with vertical or short take-off and landing (VTOL) aircraft hovering in ground effect can have a critical effect on aircraft performance, and they are modeled very poorly by existing models. Three flow phenomena representative of VTOL ground effects flows, the upwash fountain, the ground vortex, and the impingement zone of a round jet, are considered. Extensions to the k-epsilon model are presented which are designed to account for streamline curvature, large scale mixing, and anisotropy. The extensions significantly improve the model's ability to predict some aspects of these flows. Requirements for further model development are identified. Author

A91-21327#
THREE-DIMENSIONAL UNSTEADY FLOW FIELDS ELICITED BY PITCHING A CANARD AND FORWARD SWEPT WING CONFIGURATION
JAY DEANDREA, JAMES W. ROACHE, and MICHAEL C. ROBINSON (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. Research sponsored by USAF. refs
(AIAA PAPER 91-0005) Copyright

Unsteady, three-dimensional flow fields generated by sinusoidal oscillations of a combined canard/forward swept wing planform were examined across a range of dynamic parameters. Pitch motions which exceeded the planform static stall angle generated large vortical flow structures. Multiple exposure, phase locked, stroboscopic photographs documented the three-dimensional nature of both flow structures and interactions. Dynamic stall vortices were produced on both the canard and trailing wing. The flow fields in the region of the canard tip and wing tip were dominated by conical tip vortices. The unsteady separated flow fields were temporally dependent on reduced frequency. However, the flow development differed from that previously observed with a solitary forward swept wing pitched about quarter chord. The addition of the canard further complicated the flow fields by introducing additional three-dimensional structures which impinged on the trailing forward swept wing. Dynamic separation from the forward swept wing dominated the surrounding flow and altered the flow separation from the canard. Author

A91-21328#
ON THE FORMATION AND CONTROL OF THE DYNAMIC STALL VORTEX ON A PITCHING AIRFOIL
MIGUEL R. VISBAL (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. refs
(AIAA PAPER 91-0006)

Dynamic stall vortex formation is described based on laminar Navier-Stokes computations performed for an airfoil pitching at constant rate. At low Reynolds number, the vortex is initiated by

the roll-up of the strong shear layer which is created by the appearance of a thin unsteady region of flow reversal, and not by the growth of a laminar separation bubble or by the eruption of fluid particles from the surface. The effects of pitch rate, pivot location, and Reynolds number on the dynamic stall vortex formation were also investigated. It is shown that, at higher pitch rates, the process of flow reversal is more abrupt, and a thinner and stronger shear layer develops near the airfoil leading edge. The resulting vortex is smaller and forms more rapidly and closer to the leading edge. L.K.S.

A91-21329*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A STUDY OF DYNAMIC STALL USING REAL TIME INTERFEROMETRY
L. W. CARR (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), M. S. CHANDRASEKHARA (Navy-NASA Joint Institute of Aeronautics; U.S. Naval Postgraduate School, Monterey, CA), S. AHMED (MCAT Institute, San Jose, CA), and N. J. BROCK (Aerometrics, Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. Research supported by the U.S. Navy and U.S. Army. refs
(Contract AF-AFOSR-ISSA-89-0067)
(AIAA PAPER 91-0007) Copyright

Dynamic stall over an oscillating airfoil in compressible flow was studied using a real-time interferometry technique. Instantaneous flow field data was obtained for various unsteady as well as steady flow conditions. Comparison of steady flow interferograms with those taken in unsteady flow reveal a significant delay in the development of leading edge suction peaks in the unsteady case. The interferograms permit detailed analysis of the leading edge pressure field; as many as 13 pressure values have been obtained around the leading edge in the first 1 percent of the airfoil chord. The results offer a significant new insight into the character of the dynamic stall vortex, and the stall delay that is observed during dynamic motions. Author

A91-21331#
VORTICITY DYNAMICS OF 2-D AND 3-D WINGS IN UNSTEADY FREE STREAM
ISMET GURSUL, HANK LIN, and CHIH-MING HO (Southern California, University, Los Angeles, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract F49620-88-C-0061)
(AIAA PAPER 91-0010) Copyright

The response of delta wings with different aspect ratios and a two-dimensional wing in unsteady free stream was investigated in a vertical water channel. It was found that the characteristics of the lift forces depend on whether the leading edge vortex convects. For delta wings with attached leading edge vortex, the lift forces are not a function of the reduced frequency, since there is no intrinsic time scale. At large angle of attack, the leading edge vortices shed and convect downstream. Consequently, an intrinsic time scale appears and the lift depends on the reduced frequency, which is the ratio of the convection time of the vortex on the chord, to the period of the free stream variation. This is very similar to the lift characteristics of a two-dimensional wing. For the NACA-0012 airfoil, very high lift coefficients could be obtained in the post stall region by trapping a large coherent vortex on the chord for an appreciable portion of the cycle, which provides a lift coefficient larger than 10. Author

A91-21333#
EXPERIMENTAL INVESTIGATION OF A 2-D SCRAMJET INLET AT MACH NUMBERS OF 8 TO 18 AND STAGNATION TEMPERATURES OF 4,100K
M. A. S. MINUCCI (Centro Tecnico Aeroespacial, Sao Jose dos Campos, Brazil) and H. T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0013) Copyright

An investigation of the internal flow in a two-dimensional variable geometry scramjet inlet was performed using the RPI .61 m diameter Hypersonic Shock Tunnel. The stagnation conditions investigated were 4100 K and 5.5 MPa with a corresponding stagnation enthalpy of 6.5 MJ/Kg. The selected free stream Mach numbers were 8, 10, 12, 15, and 18 corresponding to free stream Reynolds numbers of 180,000-13,000/m range and free stream Knudsen numbers in the 1-32 range. Surface and pitot pressure measurements at these flow conditions indicate very complex flow structure due to the impingement of the cowl shock wave on the inlet ramp boundary layer. It is also noted that higher pitot pressures exist in the duct region at Mach 18 than those measured at Mach 15. L.K.S.

A91-21334#
CFD VALIDATION AND WIND TUNNEL TEST FOR A NASP SINGLE EXPANSION RAMP NOZZLE IN THE TRANSONIC REGIME
ISMAIL O. HINDASH and FRANK W. SPAID (McDonnell Douglas Corp., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0015) Copyright

Wind tunnel test data were obtained at Mach 1.2 to validate a two-dimensional zonal Navier-Stokes computer code for various single-expansion-ramp-nozzle flowfields. The sensitivity of computed results to variations in computational modeling parameters, such as grid topology, grid density, and turbulence modeling, has been evaluated. Various turbulence models were used. Wind tunnel measurements and CFD predictions of thrust coefficient were compared and found to agree within 5 percent (+ or - 0.0375 thrust coefficient). A parametric study of jet stagnation to freestream static pressure ratios is also provided. Author

A91-21335#
EXPERIMENTAL STUDY ON MIXING PHENOMENA IN SUPERSONIC FLOWS WITH SLOT INJECTION
SHIGERU ASO (Kyushu University, Fukuoka, Japan), MASAFUMI KAWAI, YASUNORI ANDO (Ishikawajima-Harima Heavy Industries Co., Ltd., Yokohama, Japan), and SATOSHI OKUYAMA AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0016) Copyright

The complex flowfields induced by gaseous secondary flow injected into supersonic flow have been studied experimentally at free-stream Mach 3.8, total pressure of 1.2 MPa, and Reynolds number of 2.0 x 10 to the 7th. The results show that the bow shock wave/turbulent boundary layer interaction induces the boundary layer separation in front of the injection. In the interacting flow, barrel shock waves and Mach disk are observed clearly. As the total pressure ratio or thickness of nozzle is increased, the separation region, the extent of the interaction region and shock structures enlarge significantly. Author

A91-21338*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL PREDICTION OF THE UNSTEADY FLOWFIELD AROUND THE F-18 AIRCRAFT AT LARGE INCIDENCE
YEHIA M. RIZK (NASA, Ames Research Center, Moffett Field, CA) and KEN GEE (MCAT Institute, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(AIAA PAPER 91-0020) Copyright

This paper describes a numerical method capable of solving the steady and unsteady viscous flow around complete aircraft configurations at high angles of attack. This method is used to simulate the external flow around the F-18 aircraft, including deflected control surfaces. The current technique employs a generalized overset zonal grid scheme to decompose the computational space around the aircraft. The grid around various components of the aircraft are created numerically using a three-dimensional hyperbolic grid generation procedure. The Reynolds-averaged Navier-Stokes equations are integrated using a time-accurate, implicit procedure. Results for the turbulent flow

around the F-18 aircraft at 30 degrees angle of attack show the details of the flowfield structure, including the unsteadiness created by the vortex burst and the resulting fluctuating airloads exerted on the vertical tail. The computed results agree fairly well with flight data for surface pressure, surface flow pattern, vortex burst location, and the dominant frequency for tail load fluctuations. Author

A91-21341#
NUMERICAL SIMULATION OF SUPERSONIC UNSTEADY FLOW FOR MULTIBODY CONFIGURATIONS
ABDOLLAH ARABSHAHI and DAVID L. WHITFIELD (NSF, Research Center for Computational Field Simulation; Mississippi State University, Mississippi State) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Research supported by USAF. refs
(AIAA PAPER 91-0023) Copyright

An implicit, upwind numerical scheme is presented for solving the unsteady supersonic flowfields around complex configurations. This scheme solves the time-dependent thin-layer Navier-Stokes equations in generalized time-dependent curvilinear coordinate systems. Accuracy is achieved by a conservative finite-volume discretization which satisfies the geometric conservation law in generalized moving coordinate systems. The algorithm is based on flux-difference splitting using Roe averaged variables. The scheme is up to third-order accurate in space and first-order accurate in time. The viscous and diffusive terms are treated explicitly, and the turbulence effects are modeled with the well known Baldwin and Lomax mixing length model. Computational results have been obtained for a range of configurations in the supersonic speed regime to evaluate the accuracy and reliability of the present code. The computed results show favorable agreement with experiments in the flow regions which are influenced by viscous effects. Author

A91-21343#
ON THE STABILITY OF CONDUCTION DOMINATED NATURAL CONVECTION IN NEAR-VERTICAL SLOTS AND HORIZONTAL CYLINDRICAL ANNULI
A. P. ROTHMAYER (Iowa State University of Science and Technology, Ames) and D. B. FANT (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by USAF and United Technologies Corp. refs
(AIAA PAPER 91-0027) Copyright

The stability of natural convection is examined for flow in narrow inclined slots and horizontal annuli, in the limit of high Rayleigh number and flow Prandtl number. The basic steady flow is driven by the temperature difference across the slot/annulus and the local gravitational field, whereas the instability is forced by a prescribed temperature fluctuation on the left, or inner, wall - the so-called receptivity problem. The closure of the upper and lower branches of the neutral stability curve is found to be governed by the full Navier-Stokes equations at very small gap spacings. At larger gap spacings the lower branch of the neutral stability curve is governed by a classical boundary layer problem. Along the upper branch, the flow splits into a three-region structure with a Rayleigh instability in the central inviscid region. It is argued that the entire instability process at low Prandtl numbers is effectively a Rayleigh instability, with both viscosity and exponential decay to the central core of the slot/annulus setting the boundaries of the neutral stability curve. Detailed calculations are presented for the vertical slot, while extensions for the inclined slot and cylindrical annulus are noted. Author

A91-21344#
ASYMPTOTIC THEORY IN AERODYNAMICS
J. D. COLE (Rensselaer Polytechnic Institute, Troy, NY) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 45 p. refs
(Contract AF-AFOSR-88-0037)
(AIAA PAPER 91-0028) Copyright

Asymptotic approximation to the Euler equations by limit process expansions is studied. Application is made to slender wing theory, transonic slender body theory, transonic planar wings, wind-tunnel corrections, supersonic far-fields, and hypersonic lifting wings. Various limits and asymptotic matching are discussed and important results are summarized. Author

A91-21346#
STRIP BLOWING FROM A WEDGE AT HYPERSONIC SPEEDS
A. F. MESSITER, T. C. ADAMSON, JR. (Michigan, University, Ann Arbor), and M. D. MATARRESE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 23 p. refs
(AIAA PAPER 91-0032) Copyright

Surface pressure distributions are derived when gas is injected through a strip at the surface of a thin wedge in uniform flow at high Mach number. The blowing velocities are such that the flow separates ahead of the blowing region, but the layer of blown gas remains thin. Asymptotic descriptions of the separation region and the blowing region are reviewed and extended, for weak laminar viscous interaction and a cooled surface. Author

A91-21354*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF SWEEP ANGLE AND PASSIVE RELAMINARIZATION DEVICES ON A SUPERSONIC SWEPT-CYLINDER BOUNDARY LAYER
T. R. CREEL (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0066)

The effects of passive leading-edge devices on the boundary layer of a swept cylinder in supersonic flow with very low free-stream disturbance levels are investigated. Tests are conducted at Mach 3.5 over a free-stream Reynolds number based on model diameter of 15,000 to 150,000, and sweep angles of 60 deg and 76 deg are used to evaluate possible sweep-angle effects. The devices tested include a sawtoothed leading edge, square device, and a fence. It is observed that at a sweep angle of 76 deg, relaminarization of the supersonic attachment-line flow is achieved by several of the devices, while no devices are successful at a sweep angle of 60 deg. V.T.

A91-21355*# Analytical Services and Materials, Inc., Hampton, VA.
DESIGN LIMITS OF COMPRESSIBLE NLF AIRFOILS
JEFF VIKEN (Analytical Services and Materials, Hampton, VA) and R. D. WAGNER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 33 p. refs
(AIAA PAPER 91-0067)

There has been considerable success in the design of practical low-speed natural laminar flow (NLF) airfoils, with significant profile drag reduction from conventional turbulent flow airfoils. The favorable lowspeed results give an incentive to explore the possibilities of high-subsonic speed NLF airfoil design. The design problem at higher freestream Mach numbers is more severe than for low-speed designs because these high-speed airplanes typically fly at higher chord Reynolds numbers than low-speed NLF airplanes. As the Mach number increases, the main priority changes from the use of sufficient acceleration to achieve NLF for low-drag, to the delay of separation in the far aft pressure recovery region. In this effort, NLF airfoils have been designed for Mach numbers ranging from 0.60 to 0.80 and chord Reynolds numbers of 30 x 10 to the 6th and 40 x 10 to the 6th. Author

A91-21356*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES SIMULATION OF A CLOSE-COUPLED CANARD-WING-BODY CONFIGURATION
EUGENE L. TU (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 20 p. refs
(AIAA PAPER 91-0070) Copyright

The thin-layer Navier-Stokes equations are solved for the flow

about a coplanar close-coupled canard-wing-body configuration at a transonic Mach number of 0.90 and at angles of attack ranging from 0 to 12 degrees. The influence of the canard on the wing flowfield, including canard-wing vortex interaction and wing vortex breakdown, is investigated. A study of canard downwash and canard leading-edge vortex effects, which are the primary mechanisms of the canard-wing interaction, is emphasized. Comparisons between the computations and experimental measurements of surface pressure coefficients, lift, drag and pitching moment data are favorable. A grid refinement study for configurations with and without canard shows that accurate results are obtained using a refined grid for angles of attack where vortex burst is present. At an angle of attack of approximately 12 deg, favorable canard-wing interaction which delays wing vortex breakdown is indicated by the computations and is in good agreement with experimental findings. Author

A91-21357#
THIN-LAYER NAVIER-STOKES SOLUTIONS FOR TRANSONIC MULTI-BODY INTERFERENCE
PRISCA L. LYNCH (USAF, Armament Directorate, Eglin AFB, FL) and MAGDI H. RIZK (Sverdrup Technology, Inc., Eglin AFB, FL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0071)

A thin-layer, Navier-Stokes flow solver was used to predict the aerodynamics about interfering bodies. Surface pressure distributions compared very well with available experimental data for freestream Mach numbers between 0.60 and 1.20 at an interbody separation distance of 0.8 diameters. Five separate interference regions were identified which contribute to the total interference force, which was an attractive force for all cases investigated. In general, the level of interference increases with increasing free stream Mach number, and decreases with increasing separation distance. Author

A91-21368#
OPTIMUM SPACING CONTROL OF THE MARCHING GRID GENERATION
KAZUHIRO NAKAHASHI (Osaka Prefecture, University, Sakai, Japan) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0103) Copyright

A point-wise marching procedure to generate the grid is developed for external viscous flow computations about complex geometries. The grid spacings in the marching direction are controlled by using an optimization technique in which the advancing grid surface is minimized under an isoperimetric constraint. This is physically similar to the minimization of the free surface of a liquid by the surface tension. Thus the resulting grid is expected to be naturally smooth even in concave regions. For three-dimensional problems, the method is applied to a directionally-structured, prismatic mesh. The bases of the grid cells are triangles which cover the three-dimensional surface in an unstructured manner, while the direction away from the body is structured so as to achieve an efficient computation for viscous flows. The method is applied to generate a two-dimensional structured O-grid around a multielement airfoil, and a directionally-structured grid about a wing-fuselage configuration. Author

A91-21373#
APPLICATION OF THREE-DIMENSIONAL VISCOUS ANALYSIS TO TURBOFAN FORCED MIXERS
MOHAMED A. ABOLFADL and ARUN K. SEHRA (Textron Lycoming, Stratford, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0131) Copyright

A combined analytical and experimental study was conducted to establish an analytical procedure for optimizing the design of forced mixers for application to high bypass ratio turbofan engines. This two part study involved the application of a fully three-dimensional viscous procedure to a series of mixer configurations, followed by an experimental program to validate the analytical procedure. The viscous analysis used for this study involved combining two robust and versatile codes: PARC-3D, a flow solver, with INGRID-3D grid generation code. Comparison between the Navier-Stokes solution and detailed experimental measurements were made for five different mixer configurations. Both global performance parameters and detailed temperature distributions were compared. Predicted results were found to be in excellent agreement with test data. Author

A91-21374*# Purdue Univ., West Lafayette, IN.
DEVELOPMENT OF A SOLUTION ADAPTIVE UNSTRUCTURED SCHEME FOR QUASI-3D INVISCID FLOWS THROUGH ADVANCED TURBOMACHINERY CASCADES
WILLIAM J. USAB, JR. and YI-TSANN JIANG (Purdue University, West Lafayette, IN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(Contract NAG3-1127)
(AIAA PAPER 91-0132) Copyright

The objective of the present research is to develop a general solution adaptive scheme for the accurate prediction of inviscid quasi-three-dimensional flow in advanced compressor and turbine designs. The adaptive solution scheme combines an explicit finite-volume time-marching scheme for unstructured triangular meshes and an advancing front triangular mesh scheme with a remeshing procedure for adapting the mesh as the solution evolves. The unstructured flow solver has been tested on a series of two-dimensional airfoil configurations including a three-element analytic test case presented here. Mesh adapted quasi-three-dimensional Euler solutions are presented for three spanwise stations of the NASA rotor 67 transonic fan. Computed solutions are compared with available experimental data. Author

A91-21381#
VISCOUS HIGH SPEED FLOW COMPUTATIONS BY ADAPTIVE MESH EMBEDDING TECHNIQUES
F. BASSI (Catania, Universita, Italy), F. GRASSO (Roma I, Universita, Rome, Italy), M. SAVINI (CNR-CNPM, Milan, Italy), and M. PASSALACQUA AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0149) Copyright

In the present work an adaptive mesh embedding technique has been developed for the solution of viscous high Mach number flows. The equations solved are the two-dimensional full Navier Stokes equations. A Runge Kutta finite volume formulation is used with symmetric discretization of both inviscid and viscous fluxes, and adaptive dissipation. The technique has been applied to a variety of flows over a (double ellipse) blunt body to show the effects of the topology of the adapted region on the solution accuracy. Computed results indicate that the selection of the most appropriate criterion for adaptation depends upon the physical phenomena of interest. Author

A91-21389*# Analytical Services and Materials, Inc., Hampton, VA.
CROSS-FLOW VORTEX STRUCTURE AND TRANSITION MEASUREMENTS USING MULTI-ELEMENT HOT FILMS
NAVAL K. AGARWAL, SIVA M. MANGALAM (Analytical Services and Materials, Inc., Hampton, VA), DAL V. MADDALON, and FAYETTE S. COLLIER, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0166) Copyright

An experiment on a 45-degree swept wing was conducted to study three-dimensional boundary-layer characteristics using surface-mounted, micro-thin, multi-element hot-film sensors. Cross-flow vortex structure and boundary-layer transition were measured from the simultaneously acquired signals of the hot films. Spanwise variation of the root-mean-square (RMS) hot-film signal show a local minima and maxima. The distance between two minima corresponds to the stationary cross-flow vortex wavelength and agrees with naphthalene flow-visualization results. The chordwise and spanwise variation of amplified traveling

(nonstationary) cross-flow disturbance characteristics were measured as Reynolds number was varied. The frequency of the most amplified cross-flow disturbances agrees with linear stability theory. Author

A91-21393*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN ALGEBRAIC RNG-BASED TURBULENCE MODEL FOR THREE-DIMENSIONAL TURBOMACHINERY FLOWS
K. R. KIRTLEY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(Contract NAS3-25266)
(AIAA PAPER 91-0172)

An algebraic eddy viscosity turbulence model based on Renormalization Group (RNG) theory for complex three-dimensional turbomachinery flows is presented. Modifications are made to the baseline RNG model for wakes and separated flows. The model has several advantages over popular algebraic models most notably its lack of empirically determined coefficients. The model is used to compute the mean flow in a low speed axial compressor rotor. The agreement with blade boundary layer and radial flow experimental data is very good and shows improvement over the Baldwin-Lomax model. The development of the tip leakage vortex is also well predicted. The computed wake decay also compares favorably with recent experimental data. Author

A91-21394#
CALCULATION OF THE FLOW IN A CIRCULAR S-DUCT INLET
R. H. NICHOLS (Calspan Corp.; USAF, Arnold Engineering Development Center, Arnold AFB, TN) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0174)

The flow through a circular S-duct inlet has been computed and compared to experimental data at two mass-flow rates. Computations were performed using a three-dimensional Navier-Stokes code with both an algebraic and a two-equation turbulence model. The predictions for the low mass-flow-rate condition were in excellent agreement with the experiment for both turbulence models. The predictions for the strongly separated, high mass-flow-rate case have the same trends as the experiment, but do not accurately reproduce the proper levels. The two-equation turbulence model produces better results than does the algebraic model for both mass-flow-rate cases. Author

A91-21395*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL ALGORITHM COMPARISON FOR THE ACCURATE AND EFFICIENT COMPUTATION OF HIGH-INCIDENCE VORTICAL FLOW
NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 20 p. refs
(AIAA PAPER 91-0175) Copyright

Computations from two Navier-Stokes codes, NSS and F3D, are presented for a tangent-ogive-cylinder body at high angle of attack. Features of this steady flow include a pair of primary vortices on the leeward side of the body as well as secondary vortices. The topological and physical plausibility of this vortical structure is discussed. The accuracy of these codes are assessed by comparison of the numerical solutions with experimental data. The effects of turbulence model, numerical dissipation, and grid refinement are presented. The overall efficiency of these codes are also assessed by examining their convergence rates, computational time per time step, and maximum allowable time step for time-accurate computations. Overall, the numerical results from both codes compared equally well with experimental data, however, the NSS code was found to be significantly more efficient than the F3D code. Author

A91-21396#
CALCULATION OF VORTEX FLOWFIELDS AROUND FOREBODIES AND DELTA WINGS
J. E. DEESE, R. K. AGARWAL, and J. G. JOHNSON (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(AIAA PAPER 91-0176) Copyright

A Navier-Stokes solver has been applied to the flow about forebodies and delta wings at angle of attack. For forebodies, the method is able to simulate the symmetric flow that occurs at alpha of 35 deg or less and the asymmetric flow that occurs at alpha of 35-60 deg. In addition, the method is able to simulate the vortex breakdown phenomena that occur under certain conditions for delta wings. Computational predictions of surface pressure, normal force, side force, and off-body velocity vectors are compared with experimental results for flowfields which include vortex asymmetry and/or breakdown. Author

A91-21397#
A RAPIDLY CONVERGING VISCOUS/INVISCID COUPLING CODE FOR MULTI-ELEMENT AIRFOIL CONFIGURATIONS
KAZUHIRO KUSUNOSE, LAURENCE B. WIGTON, and PAUL T. MEREDITH (Boeing Commercial Airplanes, Seattle, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0177) Copyright

A rapidly converging viscous/inviscid coupling code for two-dimensional multielement airfoil analysis has been developed. An integral procedure is employed to account for the boundary layers and viscous wakes. A finite element full potential code is used to compute the outer flow. The modified streamline H-grid for the outer inviscid flow is generated with the support of a panel code. A new quasi-simultaneous method is introduced to the viscous/inviscid coupling process to achieve rapid convergence. The present code is capable of analyzing both single and multielement airfoil configurations in laminar, transitioning and turbulent flows, including fixed or free transition, separations and reattachments. Accuracy is further enhanced by adapting the wake locations. Numerical results for two and four element airfoil configurations are compared with experimental data. Agreement is generally very good for pre-stall conditions. As results in this paper show, precise locations of transition points and wakes significantly impact flap loadings, especially near maximum lift. Author

A91-21402#
NUMERICAL INFLUENCE OF UPWIND TVD SCHEMES ON TRANSONIC AIRFOIL DRAG PREDICTION
G. SEIDER and D. HAENEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0184) Copyright

The influence of upwind TVD schemes on the solution of viscous transonic airfoil flow is investigated. A flux-difference and a flux-vector splitting formulation are used to solve the thin-layer Navier-Stokes equation. Both splitting formulations, which are designed for the solution of hyperbolic conservation laws, produce numerical dissipation which can interfere with the physical viscosity and heat conduction included in the Navier-Stokes equation. Numerical experiments are presented, investigating the impact of dissipative elements like upwind damping, entropy correction and limiter functions on the solution of steady transonic airfoil flows and in particular on the prediction of airfoil forces. Author

A91-21403#
CALCULATION OF THREE-DIMENSIONAL LOW REYNOLDS NUMBER FLOWS
TUNCER CEBECI, HSUN H. CHEN (California State University, Long Beach), and BENG P. LEE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0187) Copyright

An interactive boundary-layer stability-transition approach is used to calculate the performance characteristics of an infinite swept wing at low Reynolds numbers for several angles of attack. The inviscid flow solutions are obtained from an inviscid method based on conformal mapping and the viscous flow solutions from an inverse boundary-layer scheme which use the Hilbert integral formulation to couple the inviscid and viscous flow. The onset of transition is calculated by the e exp n method based on two- and three-dimensional versions of linear stability theory. The effect of sweep angle on lift and drag coefficients is investigated together with the accuracy of predicting the onset of transition with two versions of the e exp n method. Author

A91-21404#
AERODYNAMIC SHAPE DESIGN USING STREAM-FUNCTION-COORDINATE (SFC) FORMULATION
GEORGE S. DULIKRAVICH (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0189) Copyright

A new approach to the inverse design of two-dimensional aerodynamic shapes has been developed. This formulation is based on a Stream-Function-Coordinate (SFC) concept for steady, irrotational, compressible, inviscid, planar flows. It differs from the classical stream function formulation in that it treats the y-coordinate of each point on a streamline as a function of the x-coordinate and the stream function psi, that is, Y = Y(x,psi). This new formulation is especially suitable for the computation of stream line shapes, and therefore, for determination of aerodynamic shapes subject to specified surface pressure distributions. In addition, the SFC method is equally suitable for the analysis of the flowfields around given shapes. A computer code has been developed on the basis of SFC formulation. It is capable of performing flowfield analysis and inverse design of airfoil cascade shapes by changing a single input parameter. Author

A91-21437#
AERODYNAMIC CHARACTERISTICS OF THREE GENERIC FOREBODIES AT HIGH ANGLES OF ATTACK
FREDERICK W. ROOS and JEROME T. KEGELMAN (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract N00019-88-C-0357)
(AIAA PAPER 91-0275) Copyright

A comprehensive series of experiments has been conducted to quantitatively define the vortical flowfields of three generic forebody shapes at high angles of attack. This paper reports on the first stage of the research effort, which involved measurement of aerodynamic loads and surface pressures for the three bodies at angles of attack up to 60 degs, and for several Reynolds numbers with both laminar and turbulent separation. Forebodies with circular and elliptical cross sections developed large side forces for alpha greater than 30 degs, whereas a chined body did not generate a side force at any a. The chined body, however, developed the strongest normal force at all angles of attack. Placement of a small bump at the forebody nose stabilized the flow asymmetry for both the tangent ogive and the elliptical body. Transition strips successfully produced the simulation of high-Reynolds-number, fully turbulent flow separations. Turbulent separation reduced the nonlinear vortex lift on both the tangent ogive and the elliptical body. While side force was also reduced on the tangent ogive, it was actually increased on the elliptical body. Turbulent separation made no difference in the chined body loads. Author

A91-21438#
VISCOUS FLOW SIMULATION OF FIGHTER AIRCRAFT
OH J. KWON and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by USAF. refs
(AIAA PAPER 91-0278) Copyright

A computer code capable of solving the three-dimensional compressible, unsteady, Navier-Stokes equations has been developed. This solver has been applied to steady and unsteady subsonic flow past highly swept fighter aircraft wings and wing-body-inlet-tail combinations at high angles of attack. Calculations for isolated wings show the formation of a leading edge vortex and the resultant increase in lift. At sufficiently high angles of attack, the lift distribution over the wing begins to oscillate in time. Calculations for wings subjected to a ramp motion reveal substantially higher lift loads prior to stall than for the static fixed angle of attack conditions. The results for wing-body-inlet combinations show separated flow off the sharp inlet leading edge, vortex formation over wing-inlet interface region and over the wing leading edge. The vortex core trajectory and the flow field agree well with the experimental results. The analysis shows near-periodic fluctuations in the sectional lift coefficients with time. A Fourier analysis of the sectional lift coefficients reveals the flow field to be rich in Strouhal number-like fundamental frequencies. Calculations have also been carried out for a vertical tail configuration, which indicates large lateral forces on the vertical tail due to interaction between the vertical tail and the vortical flow off the wing-body-inlet configuration. Author

A91-21442*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYSIS OF FLOW ON CONES AND CYLINDERS USING DISCRETE VORTEX METHODS
THOMAS G. GAINER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0288) Copyright

Discrete vortex methods have been developed to investigate the vortex flows on cones and two-dimensional cylinders. The cone problem was solved by assuming that, to meet conical flow and zero-force conditions, the vortices move radially away from the body at a given cross-section. The two-dimensional cylinder problem was solved by limiting the velocity along the zero streamline surrounding the vortex field to two times freestream velocity and by limiting the lateral movement of the vortices. Variations in vortex position and strength with time were determined by taking into account the rate at which circulation is generated at separation points on the body. The calculated vortex positions and strengths were in good agreement with available experimental data. Viscous effects could be accounted for by adding empirically determined damping terms to the velocity equations. The models indicate that different types of asymmetry occur for the cone and two-dimensional cylinder. Asymmetry onset boundaries determined by the discrete vortex method show the same trend as experiment. Author

A91-21443*# Technion - Israel Inst. of Tech., Haifa.
NUMERICAL, EXPERIMENTAL, AND THEORETICAL STUDY OF CONVECTIVE INSTABILITY OF FLOWS OVER POINTED BODIES AT INCIDENCE
DAVID DEGANI (Technion - Israel Institute of Technology, Haifa) and MURRAY TOBAK (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(AIAA PAPER 91-0291) Copyright

A study is conducted to investigate whether the behavior of the asymmetric mean flow observed on pointed bodies of revolution at incidence remains consistent with the presence of a convective instability of an original symmetric flow, even in the incidence range where virtually bistable behavior of the asymmetric flow is observed. By means of a retractable wire located near the tip, it is determined experimentally that for all angles of attack tested (30 to 60 degs), changing the size or location of the controlled disturbance results in a finite change in the asymmetric flow field, even to the extent of reversing the sign of the side force or becoming almost symmetric. The process is reversible; returning the wire to an original position likewise restores the corresponding flow field and mean side force. The effect of wire location (roll angle and distance from the tip) as well as angle of attack and flow conditions are evaluated experimentally by means of flow

visualization and side-force measurements for a generic ogive-cylinder model in a low-speed wind tunnel. Evaluation of the results in the light of computational observations and theoretical considerations yields an affirmative answer to the question posed. Author

A91-21457*# Air Force Wright Research and Development Center, Wright-Patterson AFB, OH.
NONLINEAR DISTURBANCES IN A HYPERSONIC LAMINAR BOUNDARY LAYER
ROGER L. KIMMEL (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and JAMES M. KENDALL (JPL, Pasadena, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0320)

Three separate but similar experiments on the growth of naturally-occurring instability waves in the laminar boundary-layers on sharp cones at hypersonic Mach numbers have been conducted. Each provided clear evidence that the theoretically-predicted second mode of instability was responsible for high-amplitude wave trains observed to prevail upstream of boundary-layer transition to turbulence. However, each also seemed to reveal the presence of an additional instability not accounted for by the linear theory. Here, examination is made of the tape-recorded hot-wire anemometer signals of one experiment on a sharp cone at Mach 8 for evidence of nonlinearity, the finding of which would explain the presence of the additional mode as a consequence of harmonic generation. Several approaches for identification of the residual effects of nonlinearity are described and utilized. Also, a simplified model describing certain fluctuation characteristics has been developed. Altogether, the evidence of nonlinear wave development is found to be strong. Quantitative comparisons of linear theory to experiments must be made with caution when nonlinearity is present in the experiment. Author

A91-21458#
JOINT COMPUTATIONAL EXPERIMENTAL AERODYNAMICS RESEARCH ON A HYPERSONIC VEHICLE. II - COMPUTATIONAL RESULTS
MARY WALKER and WILLIAM L. OBERKAMPF (Sandia National Laboratories, Albuquerque, NM) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 91-0321) Copyright

Parabolized and iterative Navier-Stokes codes are used to predict flowfield solutions around a complex hypersonic vehicle. Aerodynamic force and moment predictions from the codes are compared with wind tunnel data from the Sandia Mach 8 hypersonic wind tunnel. The comparisons are made on a spherically blunted cone with a slice parallel to the body axis. On the sliced portion of the body a flap can be attached such that the angle of the flap is 10, 20, or 30 deg, relative to the slice. The Sandia Parabolized Navier-Stokes code is used to generate solutions for the sliced vehicle with no flap. For the vehicle with the flap, axially separated flow occurs and a time iterative Navier-Stokes code is used to provide comparisons with the data. A detailed study of grid convergence is presented to determine the accuracy of the numerical solutions. Errors in the numerical predictions on different grids are determined where Richardson extrapolation is used to estimate the exact solution. Predictions obtained from the coders show very good agreement with the experimental data for force and moment coefficients, except for large flap deflections. Author

A91-21459*# Case Western Reserve Univ., Cleveland, OH.
MOLECULAR DYNAMICS COMPUTATIONS OF TWO DIMENSIONAL SUPERSONIC RAREFIED GAS FLOW PAST BLUNT BODIES
ISAAC GREBER (Case Western Reserve University, Cleveland, OH), HAROLD Y. WACHMAN (MIT, Cambridge, MA), and MYEUNG-JOUH WOO AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. Research supported by NASA.
(AIAA PAPER 91-0322) Copyright

This paper presents results of molecular dynamics computations of supersonic flow past a circular cylinder and past a flat plate perpendicular to a supersonic stream. The results are for Mach numbers of approximately 5 and 10, for several Knudsen numbers and several ratios of surface to free stream temperatures. A special feature of the computations is the use of relatively small numbers of particles in the molecular dynamics simulation, and an examination of the adequacy of using small numbers of particles to obtain physically useful results. Author

A91-21460#
A STUDY OF COMPRESSIBLE LAMINAR BOUNDARY LAYER AT MACH NUMBERS 4 TO 30
JOSEPH E. FLAHERTY, HENRY T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY), and AUGUSTO C. M. MORAES AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Research supported by SDIO. refs
(Contract DAAL03-90-G-0096)
(AIAA PAPER 91-0323) Copyright

This investigation is the first part of a two-phase study on laminar boundary layers at the high Mach numbers and stagnation temperatures encountered by the national Aero-Space Plane. In this preliminary study, comnpressible laminar boundary layers are investigated over an adiabatic flat plate for Mach numbers 4 to 30. The Prandtl laminar boundary layer equations are solved using a finite element method with symbolic evaluation of element matrices for three different assumptions: (1) a perfect gas with constant properties and unit Prandtl number; (2) a gas with viscosity variation according to Sutherland's law; and (3) a real gas with equilibrium air properties. Results for each flow regime include streamwise and transverse velocity profiles, temperature and density distributions, recovery factors, and boundary layer thickness. Author

A91-21461*# Analytical Services and Materials, Inc., Hampton, VA.
NONPARALLEL INSTABILITY OF SUPERSONIC AND HYPERSONIC BOUNDARY LAYERS
NABIL M. EL-HADY (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(Contract NAS1-18599)
(AIAA PAPER 91-0324) Copyright

Multiple scaling technique is used to examine the nonparallel instability of supersonic and hypersonic boundary-layer flows to three-dimensional (first mode) and two-dimensional (second mode) disturbances. The method is applied to the flat plate boundary layer for a range of Mach numbers from 0 to 10. Growth rates of disturbances are calculated based on three different criteria: following the maximum of the mass-flow disturbance, using an integral of the disturbance kinetic energy, and using an integral of the square of the mass-flow amplitude. By following the maximum of the mass-flow dusturbance, the calculated nonparallel growth rates are in good quantitative agreement with the experimental results of Kendall (1967) at Mach number 4.5. Author

A91-21465#
SIMULATION OF STALL DEPARTURE USING A NONLINEAR LIFTING LINE MODEL
JOHN D. FUNK, JR. and BARNES W. MCCORMICK (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0340)

A dynamic simulation is conducted using a nonlinear lifting line model to predict the spanwise lift distribution on a wing through and beyond stall. This aerodynamic model allows for roll and yaw at high angles of attack, thus permitting a dynamic simulation of stall. The nonlinear lifting line model uses a combination of wind tunnel data and analysis to find the lift and drag at any location on the wing. Circulation in the wake resulting from spanwise lift variations is considered. Forces on the tail surfaces and fuselage are approximated by linear relations performed on representative sections. The aerodynamic forces are integrated over time using

six-degree-of-freedom equations of motion. The result is a time history of all aircraft orientations and velocities during a wings-level stall. This result is compared to flight test data. Author

A91-21484#
SLENDER WING ROCK REVISITED
LARS E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. Research supported by the Lockheed Missiles and Space Co., Inc. refs
(AIAA PAPER 91-0417) Copyright

Analysis of experimental results for slender delta wings reveals that several flow phenomena play a role in the observed wing rock motions. The relative importance of the various flow mechanisms is determined by leading edge sweep and angles of attack and sideslip. The underlying fluid mechanics are analyzed, laying the foundation for future development of means for predicting not only when wing rock will occur but also how wing rock characteristics, such as limit cycle amplitude and oscillation frequency, depend on wing geometry and flight conditions. Author

A91-21491*# Illinois Univ., Urbana.
EFFECT OF A SIMULATED ICE ACCRETION ON THE AERODYNAMICS OF A SWEPT WING
M. B. BRAGG, A. KHODADOUST, R. SOLTANI, S. WELLS, and M. KERHO (Illinois, University, Urbana) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. Research supported by NASA and University of Illinois. refs
(AIAA PAPER 91-0442) Copyright

The effect of a simulated glaze ice accretion on the aerodynamic performance of a three-dimensional swept wing is studied experimentally. A semispan wing of effective aspect ratio four was mounted from the sidewall of the UIUC subsonic wind tunnel. The model uses a NACA 0012 airfoil section on a rectangular planform with interchangeable tip and root sections to allow for 0- and 30-degree sweep. A sidewall suction system is used to minmize the tunnel boundary-layer interaction with the model. Surface pressure data from five spanwise stations are compared to earlier data from a similar tunnel. A three-component sidewall balance has been designed, built and used to measure lift, drag and pitching moment on the clean and iced model. The data compare well to the integrated pressure data and to theory on the clean model. In addition, helium-bubble flow visualization has been performed on the iced model and reveals extensive spanwise flow in the separation bubble aft of the upper surface horn. This compares well to the computational results of other researchers. Sidewall suction was found to have no effect on the aerodynamics of the swept wing. Author

A91-21492#
AERODYNAMIC EFFECTS OF DISTRIBUTED ROUGHNESS ON A NACA 63(2)-015 AIRFOIL
B. OOLBEKKINK and D. F. VOLKERS (Fokker Aircraft, Amsterdam, Netherlands) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(AIAA PAPER 91-0443) Copyright

This paper describes a wind tunnel test on an NACA 63(2)-015 airfoil with several configurations of distributed roughness on the upper surface. Experimental and calculated lift losses are presented for an angle of attack of 8.4 deg. It is shown that both the size and the extent of the roughness have an effect on the lift of the airfoil. The loss of lift is correlated with the increase in the boundary layer displacement thickness near the trailing edge of the model. The prediction of this increase, and of the loss of lift, by the computer code are at a lower level. Author

A91-21493*# Wichita State Univ., KS.
EXPERIMENTAL WATER DROPLET IMPINGEMENT DATA ON MODERN AIRCRAFT SURFACES
MICHAEL PAPADAKIS (Wichita State University, KS), MARLIN D. BREER, NEIL C. CRAIG (Boeing Co., Wichita, KS), and COLIN S. BIDWELL (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. Research supported by FAA. refs
(Contract NAG3-566)
(AIAA PAPER 91-0445) Copyright

An experimental method has been developed to determine the water droplet impingement characteristics on two- and three-dimensional aircraft surfaces. The experimental water droplet impingement data are used to validate particle trajectory analysis codes that are used in aircraft icing analyses and engine inlet particle separator analyses. The aircraft surface is covered with thin strips of blotter paper in areas of interest. The surface is then exposed to an airstream that contains a dyed-water spray cloud. The water droplet impingement data are extracted from the dyed blotter paper strips by measuring the optical reflectance of each strip with an automated reflectometer. Preliminary experimental and analytical impingement efficiency data are presented for a NLF(1)-0414F airfoil, s swept MS(1)-0317 airfoil, a swept NACA 0012 wingtip and for a Boeing 737-300 engine inlet model. Author

A91-21495#
MODELING TWO-POINT SPATIAL TURBULENCE SPECTRA FOR ANALYSIS OF GUST VARIATIONS OVER AEROSPACE VEHICLES
JOSEPH E. DURHAM, JR. (U.S. Army, Missile and Space Intelligence Center, Redstone Arsenal, AL) and WALTER FROST (Tennessee, University, Tullahoma) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0449) Copyright

Analytical models for two-point spatial spectra of atmospheric turbulence are developed. Models based on both the von Karman and Dryden correlation are presented. A two-point auto-correlation, defined as the correlation between like components of velocity measured at two spatially separated positions, is Fourier transformed to give the spectrum. A discussion of the bias and aliasing errors associated with fast Fourier transform techniques for two-point correlations is presented. A comparison is given of the spectrum computed by the fast Fourier transform of the digitized analytical correlation, and of the experimental data directly. The results demonstrate that the two-point auto-spectrum is extremely sensitive to bias errors. Filters for smoothing the data to minimize the bias error are investigated and an optimum filter is proposed. Author

A91-21505*# Old Dominion Univ., Norfolk, VA.
AERODYNAMIC DESIGN OPTIMIZATION USING SENSITIVITY ANALYSIS AND COMPUTATIONAL FLUID DYNAMICS
OKTAY BAYSAL and MOHAMED E. ELESHAKY (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NAG1-1188)
(AIAA PAPER 91-0471) Copyright

A new and efficient method is presented for aerodynamic design optimization, which is based on a computational fluid dynamics (CFD)-sensitivity analysis algorithm. The method is applied to design a scramjet-afterbody configuration for an optimized axial thrust. The Euler equations are solved for the inviscid analysis of the flow, which in turn provides the objective function and the constraints. The CFD analysis is then coupled with the optimization procedure that uses a constrained minimization method. The sensitivity coefficients, i.e. gradients of the objective function and the constraints, needed for the optimization are obtained using a quasi-analytical method rather than the traditional brute force method of finite difference approximations. During the one-dimensional search of the optimization procedure, an approximate flow analysis (predicted flow) based on a first-order Taylor series expansion is used to reduce the computational cost. Finally, the sensitivity of the optimum objective function to various design parameters, which are kept constant during the optimization, is computed to predict new optimum solutions. The flow analysis of the demonstrative example are compared with the experimental data. It is shown

that the method is more efficient than the traditional methods. Author

A91-21506#
AERODYNAMIC SHAPE DESIGN AND OPTIMIZATION
GEORGE S. DULIKRAVICH (Pennsylvania State University, University Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0476) Copyright

Realistic aerodynamic shapes can be designed using methodologies from computational fluid dynamics and optimization. Two basic categories of the inverse (design) formulation are surface flow design and flow field design. Several methods, in both categories, including novel methods based on flow control theory, are being discussed and critically evaluated. Many issues remain unresolved. These issues include: specification of a more appropriate set of design constraints, acceleration of iterative algorithms, minimization of artificial dissipation, increased versatility of the design methods, and direct use of the existing and future flow field analysis software. Author

A91-21517#
NUMERICAL INVESTIGATION OF DRAG REDUCTION IN FLOW OVER SURFACES WITH STREAMWISE ALIGNED RIBLETS
DOUGLAS CHU and GEORGE E. KARNIADAKIS (Princeton University, NJ) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract NSF CTS-89-06432; NSF CTS-89-14422)
(AIAA PAPER 91-0518) Copyright

The flow in a channel with its lower wall mounted with riblets that are aligned along the streamwise direction is investigated numerically using three-dimensional spectral element simulations. The particular riblet configuration considered is symmetric V-shaped grooves with height h equal to their base s. The range of Reynolds numbers investigated is 500 to 3500, which corresponds to laminar and transitional flow states. The results suggest that in the laminar regime there is no drag reduction, while in the transitional regime drag reduction up to ten percent exists for the lower grooved wall in comparison with the upper smooth wall of the channel; in the latter case, good agreement exists with available experimental data and empirical correlations. Author

A91-21518#
DETAILED DOCUMENTATION OF THE NEAR FIELD EFFECTS OF LARGE EDDY BREAK UP DEVICES ON THE ONCOMING VORTICAL STRUCTURES IN TURBULENT BOUNDARY LAYERS
Y. G. GUEZENNEC (Ohio State University, Columbus) and N. TRIGUI AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract NSF MSM-87-09154; AF-AFOSR-89-0434)
(AIAA PAPER 91-0519) Copyright

The near field effect of a single Large Eddy Break Up device (LEBU) on the oncoming vortical structure in a turbulent boundary layer was investigated in great detail by measuring the full two-point space-time correlation tensor. In addition to conventional turbulence moments, spatial and temporal integral scales were determined. The stochastic estimation technique was used to reconstruct estimates of the full three-dimensional spatio-temporal evolution of the vortical structures as they pass over the manipulator: the name 'Large Eddy Break Up' device is indeed justified to the results obtained here. It was found that in addition to the obvious inhibition of the normal velocity component by the LEBU, a number of other interrelated mechanisms are at play. Author

A91-21525#
STUDY OF DYNAMIC STALL MECHANISM USING SIMULATION OF TWO-DIMENSIONAL UNSTEADY NAVIER-STOKES EQUATIONS
K. N. GHIA, J. YANG, G. A. OSSWALD, and U. GHIA (Cincinnati, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(Contract AF-AFOSR-90-0249)
(AIAA PAPER 91-0546) Copyright

An unsteady Navier-Stokes analysis in velocity-vorticity variables is extended to higher Reynolds numbers. The convective derivatives in the known vorticity transport equation are approximated using a third-order biased upwind differencing scheme (UDS), with all other spatial derivatives still being approximated using the central difference scheme. A test configuration for a NACA 0015 airfoil is selected with the Reynolds numbers of 10,000 and 45,000 and constant pitch-up motion. The third-order biased UDS is shown to be satisfactory for obtaining results up to the Reynolds number of 45,000. A separation bubble embedded within the boundary layer is observed between the leading edge and the quarter-chord point (QCP). If the separation bubble is controlled through suction in the appropriate vicinity of QCP, the dynamic stall may be delayed and/or prevented. V.T.

A91-21549#
TECHNIQUES FOR ACCURATE, EFFICIENT COMPUTATION OF UNSTEADY TRANSONIC FLOW
T. H. SHIEH, JEFFREY G. SCHOEN, and K.-Y. FUNG (Arizona, University, Tucson) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(Contract AF-AFOSR-83-0071)
(AIAA PAPER 91-0597) Copyright

This paper describes the development of an accurate and efficient computer code for transonic flutter prediction. The unique features of this code, to be called ZUNAS, are the capability of accepting a steady mean flow regardless of its origin, a time dependent perturbation boundary condition on the steady mean surface, and a new locally applied three-dimensional far-field boundary condition. Results obtained using this code show good agreement with experiment and other theories. Nonlinear effects, viscous effects, and other important features in unsteady transonic flow computation can be delineated from these results. The techniques introduced here can easily be adopted for other methods to achieve similar savings in computational resources. Author

A91-21550#
A COMPOSITE GRID APPROACH TO STUDY THE FLOW SURROUNDING A PITCH-UP AIRFOIL IN A WIND TUNNEL
TAEKYU REU and SUSAN X. YING (Florida State University, Tallahassee) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. refs
(Contract DE-FC05-85ER-25000)
(AIAA PAPER 91-0599) Copyright

This paper presents an unsteady Navier-Stokes algorithm featuring a composite grid scheme to solve the flow over a pitch-up airfoil inside a wind tunnel. The composite grid consists of structured grids with wall boundaries and an unstructured grid which fills up the gap between the structured grids. A second order implicit iterative scheme and a third order upwind cell centered finite volume method are employed for the algorithm. The results are validated against measurement. Moreover, the pitch-up simulations are carried out to higher angle of attack than available experimental data. The development of the flow structures seen from these transient high angle of attack solutions yields better understanding of dynamic stall. Author

A91-21551*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CALCULATION OF FLOW ABOUT TWO-DIMENSIONAL BODIES BY MEANS OF THE VELOCITY-VORTICITY FORMULATION ON A STAGGERED GRID
PAUL M. STREMEL (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0600) Copyright

A method for calculating the incompressible viscous flow about two-dimensional bodies, utilizing the velocity-vorticity form of the Navier-Stokes equations using a staggered-grid formulation is

presented. The solution is obtained by employing an alternative-direction implicit method for the solution of the block tridiagonal matrix resulting from the finite-difference representation of the governing equations. The boundary vorticity and the conservation of mass are calculated implicitly as a part of the solution. The mass conservation is calculated to machine zero for the duration of the computation. Calculations for the flow about a circular cylinder, a 2-pct thick flat plate at 90-deg incidence, an elliptic cylinder at 45-deg incidence, and a NACA 0012, with and without a deflected flap, at - 90-deg incidence are performed and compared with the results of other numerical investigations. V.T.

A91-21558*# Syracuse Univ., NY.
THE SYMMETRIC TURBULENT PLANE WAKE DOWNSTREAM OF A SHARP TRAILING EDGE
E. A. BOGUCZ (Syracuse University, NY) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research supported by NASA and Syracuse University. refs
(AIAA PAPER 91-0612) Copyright

The analysis and modeling of the symmetric turbulent plane wake downstream of a sharp trailing edge is addressed. A compact description of the flow near the trailing edge is formulated using the results of a previous asymptotic analysis. The new description retains the two-layered structure identified in the previous work, and it clarifies the principal dynamics of the flow in the near-wake outer layer, away from the wake centerline. For zero-pressure-gradient flow, the near-wake outer layer is shown to be represented to leading order by the similarity solution that governs the outer region of the surface boundary layer. The leading perturbation in the outer layer due to the developing near-wake inner-layer flow is identified, and this is shown to be asymptotically smaller than undetermined higher-order terms associated with the surface boundary-layer flow. Results of the new near-wake analysis are used to formulate an algebraic eddy viscosity model for wake flow predictions at arbitrary distances from the trailing edge. The model is used in a numerical solution of the boundary layer equations, and computed velocity and Reynolds stress profiles are shown to compare well with experimental data. Author

A91-21561*# Stanford Univ., CA.
HIGH ALPHA AERODYNAMIC CONTROL BY TANGENTIAL FUSELAGE BLOWING
G. I. FONT and DOMINGO A. TAVELLA (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(Contract NCC2-55)
(AIAA PAPER 91-0620) Copyright

This work explores the effect of tangential blowing on the vortical structures that develop around a tangent-ogive cylinder configuration at high angle of attack. A lateral force results if blowing is applied asymmetrically. The study is conducted numerically by solving the three-dimensional, compressible-flow Navier-Stokes equations. The computation was done for a Reynolds number of 52,000, Mach number of 0.2, blowing momentum coefficients of 0.0, 0.1, 0.2, and 0.4, and angle of attack of 10, 30, and 45 deg. Only asymmetrical blowing was considered. Surface streamlines, helicity contours and pressure distributions are obtained for each case. Author

A91-21562#
A THEORY FOR TANGENTIAL FUSELAGE BLOWING
DOMINGO A. TAVELLA (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 6 p.
(AIAA PAPER 91-0621) Copyright

A theoretical model for the physics of tangential fuselage blowing is proposed. The fundamental assumption of the theory is that the yawing moment produced by tangential blowing arises from vorticity generated by the jet through its external shear layer. Some of this vorticity becomes bound, resulting in a lateral force. A simple version of the theory is applied to an ogive-cylinder configuration through a discrete vortex representation of the jet-generated vorticity. Author

A91-21573#
A SYSTEMATIC COMPARATIVE STUDY OF SEVERAL HIGH RESOLUTION SCHEMES FOR COMPLEX PROBLEMS IN HIGH SPEED FLOWS
NORBERT KROLL (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), DATTA GAITONDE, and MICHAEL AFTOSMIS (USAF, Wright Laboratory, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 39 p. refs
(AIAA PAPER 91-0636) Copyright

Five different MUSCL and non-MUSCL higher order upwind schemes were evaluated to determine their ability to accurately model the fluxes of the Euler equations for problems containing complex shock structures. The MUSCL scheme included the Steger Warming and van Leer flux vector split schemes and the Roe flux difference split scheme; the two non-MUSCL schemes were the 'Symmetric' and 'Upwind' TVD methods of Yee and Harten and Yee. The discrete solutions obtained with the Upwind TVD and Roe flux difference splitting are found to be the least diffusive of the upwind methods considered. The two schemes are also the most successfull in resolving features with a characteristic dimension on the order of the grid spacing. V.L.

A91-21574*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNSTRUCTURED EULER FLOW SOLUTIONS USING HEXAHEDRAL CELL REFINEMENT
JOHN E. MELTON, GELSOMINA CAPPUCCIO (NASA, Ames Research Center, Moffett Field, CA), and SCOTT D. THOMAS (Sterling Federal Systems, Inc., Palo Alto, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 44 p. refs
(AIAA PAPER 91-0637) Copyright

An attempt is made to extend grid refinement into three dimensions by using unstructured hexahedral grids. The flow solver is developed using the TIGER (topologically Independent Grid, Euler Refinement) as the starting point. The program uses an unstructured hexahedral mesh and a modified version of the Jameson four-stage, finite-volume Runge-Kutta algorithm for integration of the Euler equations. The unstructured mesh allows for local refinement appropriate for each freestream condition, thereby concentrating mesh cells in the regions of greatest interest. This increases the computational efficiency because the refinement is not required to extend throughout the entire flow field. V.L.

A91-21576# Texas Univ., Austin.
WALL PRESSURE FLUCTUATIONS NEAR SEPARATION IN A MACH 5, SHARP FIN-INDUCED TURBULENT INTERACTION
BERRY T. GIBSON and DAVID S. DOLLING (Texas, University, Austin) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Research supported by USAF and U. S. Navy. refs
(Contract NAG1-1005; NAGW-964)
(AIAA PAPER 91-0646) Copyright

Fluctuating surface pressure measurements have been made near separation in a Mach 5, swept shock/turbulent boundary-layer interaction induced by a sharp fin at angles of attack of 16 and 18 deg. Pressure signals in the initial compression region indicate a 'shuddering' compression fan, in contrast to a translating separation shock found previously in fin interactions at Mach 3. Therefore, shock strength does not appear to be a dominant factor in provoking interaction unsteadiness. The results show that the frequency range of the shuddering may scale on the large-eddy frequency of the incoming boundary layer, and that the intensity of the fluctuations may depend on the degree of interaction 'sweep'. Measurements along a conical ray downstream of the initial compression show that the fluctuation rms increases spanwise. Author

A91-21577#
THE EFFECTS OF MASS REMOVAL ON TURBULENCE PROPERTIES IN A NORMAL-SHOCK/TURBULENT-BOUNDARY-LAYER INTERACTION

M. J. MORRIS and M. SAJBEN (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0647) Copyright

Nominally two-dimensional interactions of a normal shock with a turbulent boundary layer were investigated experimentally, with and without mass removal. The approach flow was uniform at a freestream Mach number of 1.48 and the subsonic flow downstream of the shock was subject to an adverse pressure gradient. Most of the boundary layer flow was removed through a finely perforated plate just upstream of the foot of the shock. Laser Doppler velocimetry was used to determine the velocity field, including time-mean and turbulence properties. The mean flows have been presented in an earlier publication; this paper characterizes the turbulence fields of both interactions. Bleed eliminated the separation present in the solid wall case and changed the turbulence properties drastically. The streamwise rate of growth of turbulence kinetic energy across the interaction was substantially reduced as was the turbulence intensity level in the boundary layer emerging from the interaction. The shear stress distributions displayed a comparable trend. As implied by these changes, the turbulence production rates were significantly lower with bleed. The degree of anisotropy was reduced. Author

A91-21578# Texas Univ., Austin.
CORRELATION OF SEPARATION SHOCK MOTION IN A CYLINDER-INDUCED, MACH 5, TURBULENT INTERACTION WITH PRESSURE FLUCTUATIONS IN THE SEPARATED FLOW
D. S. DOLLING and L. BRUSNIAK (Texas, University, Austin) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. Research supported by USAF and U.S. Navy. refs
(Contract NAG3-1023; NAGW-964)
(AIAA PAPER 91-0650) Copyright

Simultaneous measurements of wall-pressure signals in the region of separation shock motion and in the separated flow downstream are taken in order to determine whether pressure variations under the separated flow correlate with specific shock motions and whether these pressure variations precede or follow the shock motions. Ensemble-averaging methods are utilized, and the individual pressure ensembles on the downstream channels and their relationship with specific shock motions are analyzed. Cross-correlations between pressure fluctuations generated by the translating separation shock wave and those under the vortex at various downstream stations are found to have large negative maxima at negative time delays, while ensemble-averaged pressure histories on the same channels show upstream propagation of large pressure pulses prior to changes in the direction of motion of the shock wave. V.T.

A91-21580*# Georgia Inst. of Tech., Atlanta.
NUMERICAL STUDY OF THE EFFECTS OF ICING ON FIXED AND ROTARY WING PERFORMANCE
OH J. KWON and LAKSHMI N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NAG3-768)
(AIAA PAPER 91-0662) Copyright

The sectional and total aerodynamic load characteristics and performance degradation of swept wings and helicopter rotors have been studied using a three-dimensional, compressible Navier-Stokes solver. Correlations of predictions with experimental data for swept wings with and without leading-edge ice formation show the ability of the present computational technique to accurately predict both the distributed surface pressures and integrated sectional loads. The leading-edge flow separation and reattachment on the wing surface associated with the leading-edge ice are also captured well showing a vortex formation and the spanwise migration of the flow inside the separated flow region. In the case of the helicopter rotors in hover, the rotor thrust loss and the torque penalties due to the leading-edge ice formation are numerically demonstrated. Author

A91-21591#
SYNERGISTIC EFFECTS OF HYDROGEN TRANSPIRATION ON COMPRESSION SURFACES FOR HYPERSONIC VEHICLES
A. M. TAGGART and E. RESHOTKO (Case Western Reserve University, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. refs
(AIAA PAPER 91-0699) Copyright

The purpose of this work is to determine whether hydrogen transpiration cooling is: (1) an effective means of thermally protecting an airframe-integrated compression surface on a hypersonic flight vehicle; and (2) a feasible method of introducing a hydrogen fuel pre-mix into the airflow entering the scramjet engines on such a vehicle. To accomplish this, laminar-to-turbulent boundary layer flows are numerically modeled over two-dimensional, hydrogen transpiration-cooled compression surfaces at freestream Mach numbers = 8, 12, and 16. The focus is on determining the maximum injection rates that the boundary layers can support without premature separation. In addition, ignition delay times are computed at selected streamwise stations to determine whether the hydrogen in the boundary layers will combust before the engine inlet. Results from this analysis indicate that turbulent flow is more desirable than laminar flow for both cooling and premixing purposes as greater quantities of hydrogen can be injected without premature flow separation. Author

A91-21592#
VISCOUS NON EQUILIBRIUM FLOW CALCULATIONS BY AN IMPLICIT FINITE VOLUME METHOD
C. FLAMENT, F. COQUEL, C. MARMIGNON, and H. HOLLANDERS (ONERA, Chatillon, France) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by DRET. refs
(AIAA PAPER 91-0702) Copyright

A fully coupled implicit finite volume method for calculating axisymmetric viscous flows with thermal and chemical nonequilibrium is presented. The numerical approximation of the governing equations is derived using a second order upwind scheme of Harten-Yee type for the inviscid fluxes and a space centered scheme for the viscous fluxes. Numerical fluxes and sources terms are fully coupled in the implicit step. A particular attention is paid on the physical models involved in this study. New transport models for species diffusion and thermal conductivities for internal mode are introduced. Furthermore, an original dissociation-vibration coupling derived from Park's approach and including the influence of reaction rates on vibrational relaxation is proposed. Results are first presented for a two-dimensional axisymmetric thermo-chemical nonequilibrium flow around a sphere-cylinder. The influence of physical models is discussed. Comparisons are performed with available numerical results and show a rather good agreement. The second application deals with the two-dimensional axisymmetric flow around a hyperboloid simulating a shuttle shape in a hyperenthalpic nozzle flow. Author

A91-21593*# Stanford Univ., CA.
NAVIER-STOKES COMPUTATION OF WING/ROTOR INTERACTION FOR A TILT ROTOR IN HOVER
IAN FEJTEK and LEONARD ROBERTS (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract NCC2-55)
(AIAA PAPER 91-0707) Copyright

A method has been developed to analyze the wing/rotor interaction of tilt rotor aircraft in hover. The unsteady, thin-layer compressible Navier-Stokes equations are solved using an implicit, finite difference scheme that employs LU-ADI factorization. The rotor is modeled as an actuator disk which imparts a radial and azimuthal distribution of pressure rise and swirl to the flowfield. The 'chimera' approach of grid point blanking is used to update the rotor boundary conditions. Results are presented for both a rotor alone and for wing/rotor interaction where the thrust coefficient is 0.0164 and wing flap deflection is 67 degrees. Many of the complex flow features are captured including the fountain

effect, leading and trailing edge separation, and the unsteady wake beneath the wing. Wing surface pressures compare fairly well with experimental data although the time-averaged download is about twenty percent higher than the measured value. This discrepancy is due to a combination of factors that are discussed. Author

A91-21598*# Washington Univ., Seattle.
SYMMETRY PLANE MODEL FOR TURBULENT FLOWS WITH VORTEX GENERATORS
GILLES L. ARNAUD and DAVID A. RUSSELL (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(Contract NAG2-283)
(AIAA PAPER 91-0723) Copyright

An approximate procedure is proposed for predicting the performance of counterrotating vortex-generator installations in incompressible flow. An inviscid calculation that includes the motion of the vortices is used to obtain crossflow velocities at the boundary-layer edge as a function of initial position, spacing, and strength of the vortices, and local values of the spanwise gradient are then folded into an integral turbulent-boundary layer procedure applied in the plane of symmetry. Special attention is paid to the consistency of the approximations and equations used. The two-dimensional aerodynamics of vortex generator installations on a NACA 0016 airfoil at angle-of-attack are estimated in this manner, and the results compared with experiments carried out with a 30-cm chord wing mounted in a 2.4 x 3.6-m cross-section wind tunnel and tested at chord Reynolds numbers of 0.7 and 1.4 x 10 to the 6th. Agreement in the separation location is found for these complex flows for a range of conditions. Author

A91-21600#
MULTI-SENSOR INVESTIGATION OF DELTA WING HIGH-ALPHA AERODYNAMICS
O. K. REDINIOTIS, N. T. HOANG, and D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(Contract AF-AFOSR-89-0283)
(AIAA PAPER 91-0735) Copyright

The flow over a slender delta wing at high angles of attack, alpha = 28 deg and 40 deg is investigated. A multiplicity of sensors are employed, namely surface pressure taps, seven-hole probes, a fiber-optic LDV probe, and flow visualization. The accuracy of different sensors and their possible interference with the flow is examined. Special attention is directed at the phenomenon of vortex breakdown. Author

A91-21603#
COMPRESSIBILITY EFFECTS ON THE SUPERSONIC REACTING MIXING LAYER
O. H. PLANCHE and W. C. REYNOLDS (Stanford University, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. Research supported by USAF. refs
(AIAA PAPER 91-0739) Copyright

The effects of heat release and compressibility on the flow stability and on the obliquity of the disturbance waves are examined through a linear inviscid stability analysis for the plane reacting compressible shear layer. The results indicate that the obliquity of the disturbance waves is reduced by increased heat release. It is shown that the reacting mixing layer can be viewed as a system of two interacting shear layers. Disturbance modes associated with either the fast or the slow stream exist for short wavelengths, while for long wavelengths the modes are associated with the entire shear layer. It is shown that the 'flame convective Mach number' is preferable to the usual convective Mach number as a parameter for correlating reacting shear layer compressibility. The results suggest the possibility of controlling the mixing rate by judicious positioning of the flame sheet. L.K.S.

A91-21604*# Old Dominion Univ., Norfolk, VA.
COMPUTATION OF STEADY AND UNSTEADY COMPRESSIBLE QUASI-AXISYMMETRIC VORTEX FLOW AND BREAKDOWN
OSAMA A. KANDIL, HAMDY A. KANDIL (Old Dominion University, Norfolk, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(Contract NAG1-994)
(AIAA PAPER 91-0752)

The unsteady, compressible Navier-Stokes equations are used to compute and analyze compressible quasi-axisymmetric isolated vortices. The Navier-Stokes equations are solved using an implicit, upwind, flux-difference splitting finite-volume scheme. The developed three-dimensional solver has been verified by comparing its solution profiles with those of a slender, quasi-axisymmetric vortex solver for a subsonic, isolated quasi-axisymmetric vortex in an unbounded domain. The Navier-Stokes solver is then used to solve for a supersonic quasi-axisymmetric vortex flow in a configured circular duct. Steady and unsteady vortex-shock interactions and breakdown have been captured. The problem has also been calculated using the Euler solver of the same code and the results are compared with those of the Navier-Stokes solver. The effect of the initial swirl has been tentatively studied. Author

A91-21605*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL INVESTIGATION OF THE FLOW OVER A DOUBLE DELTA WING AT HIGH INCIDENCE
JOHN A. EKATERINARIS (NASA, Ames Research Center; U.S. Navy-NASA Joint Institute of Aeronautics, Moffett Field, CA), RAYMOND L. COUTLEY (U.S. Navy, Naval Test Pilot School, Patuxent River, MD), MAX F. PLATZER (U.S. Naval Postgraduate School, Monterey, CA), and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 91-0753) Copyright

The vortical flowfield over a double-delta wing configuration, consisting of a sharp leading edge 76 deg sweep strake and a 40 deg sweep wing section is investigated. The governing equations are solved numerically with a partially upwind, finite-difference, factorized algorithm. The leeward side vortex system resulting from the strake and wing vortices is investigated for subsonic, high-Reynolds-number flow at various angles of incidence. At low angles of attack the strake and wing vortices remain separate over the wing section, while for flows at higher angles of attack the two vortices merge and vortex breakdown develops. Vortex breakdown appears initially at the trailing edge region of the wing section. As the angle of attack increases bursting occurs further upstream closer to the strake section. The effect of numerical grid density is investigated, and the solutions are compared with available experimental data. Author

A91-21606#
CALCULATION OF IMPINGING JET FLOWS WITH REYNOLDS STRESS MODELS
ROBERT E. CHILDS (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by DARPA and USAF. refs
(AIAA PAPER 91-0754) Copyright

The accuracy of the Reynolds-stress transport model is evaluated for two impinging jet flow phenomena important to VSTOL aircraft, the upwash fountain and the ground vortex. Models for the pressure-strain term recently proposed by Gibson and Younis and by Sarkar and Speziale were examined, and they were found to provide no significant improvement over the earlier model of Gibson and Launder for the upwash fountain. Poor accuracy for the upwash was obtained from all versions of the Reynolds-stress transport model tested here. The Gibson and

Launder model gave a reasonable estimate of the location of the core of the ground vortex, although this result may be fortuitous. Author

A91-21608#
FLIGHT AND WIND TUNNEL TESTS OF THE AERODYNAMIC EFFECTS OF AIRCRAFT GROUND DEICING/ANTI-ICING FLUIDS
EUGENE G. HILL and THOMAS A. ZIERTEN (Boeing Commercial Airplanes, Seattle, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(AIAA PAPER 91-0762) Copyright

This paper presents the results of flight and wind tunnel investigations of the aerodynamic effects of aircraft ground deicing/anti-icing fluids on a Boeing 737-200ADV. The flight tests were performed in Kuopio, Finland, and the wind tunnel tests were performed at the NASA Lewis Research Center Icing Research Tunnel. Both types of commonly used fluids, those characterized by Newtonian and non-Newtonian viscosity behavior, were evaluated. Results of the tests indicate that the fluids remain on aircraft surfaces until well after liftoff and may cause measurable lift loss and drag increase, depending on temperature, dilution, and specific characteristics of each fluid. A secondary wave of fluid that occurred at takeoff rotation was observed. Capillary wave action within the secondary wave is considered to be the source of the fluid's adverse aerodynamic effects at high angles of attack. Wind tunnel testing and computational fluid dynamics analysis indicate that the fluid effects are airplane configuration dependent. The paper also describes how results from these tests, other data, and airplane performance analyses were used to define an aerodynamic acceptance test for the fluids. Author

A91-21610*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN IMPROVED THREE-DIMENSIONAL AERODYNAMICS MODEL FOR HELICOPTER AIRLOADS PREDICTION
ROGER C. STRAWN (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and JOHN O. BRIDGEMAN (Woodside Summit Group, Inc., Mountain View, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0767) Copyright

The importance of unsteady aerodynamic effects due to rotor blade motion is demonstrated for a helicopter in high-speed forward flight. These unsteady effects are modeled as surface boundary conditions to a three-dimensional, unsteady Computational Fluid Dynamics (CFD) code called the Full-Potential Rotor Code (FPR). These boundary conditions cause significant changes in the computed lift and pitching moment at the front and rear of the rotor disk. Airloads from the modified FPR code are then iteratively coupled with the helicopter comprehensive code, CAMRAD/JA. Computed airloads show good agreement with flight-test data when lift values from the FPR code are used in the coupled calculation. However, the computed airloads from CAMRAD/JA along also show good agreement with the experimental data. Thus for this case one cannot demonstrate a significant improvement in computed airloads with the hybrid coupled scheme. The addition of the pitching moment values from the FPR code into the CAMRAD/JA calculation slows down the overall iterative convergence and does not yield any improvement in the final results. Author

A91-21611#
THE GROUND VORTEX FORMED BY IMPINGING JETS IN CROSS-FLOW
K. KNOWLES and D. BRAY (Royal Military College of Science, Shrivenham, England) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. Research supported by the British Aerospace, PLC. refs
(AIAA PAPER 91-0768) Copyright

The parameters affecting the position of the ground vortex formed by single and twin impinging jets in cross flow were investigated experimentally and numerically. The results confirm the existence of a constant relationship between the penetration distance, the separation distance, and the position of the vortex core. Any of the above parameters can thus be used to quantify ground sheet forward penetration. The relationship between the penetration and separation distances seems to hold for single and twin nozzles acrosss the complete range of parameters tested. V.L.

A91-21616*# University of Southern California, Los Angeles.
A SHOCK-LAYER THEORY BASED ON THIRTEEN-MOMENT EQUATIONS AND DSMC CALCULATIONS OF RAREFIED HYPERSONIC FLOWS
H. K. CHENG, ERIC Y. WONG (Southern California, University, Los Angeles, CA), and V. K. DOGRA (Vigyan Research Associates, Inc, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. Research supported by DOD and USAF. refs
(Contract NAGW-1061)
(AIAA PAPER 91-0783) Copyright

Grad's thirteen-moment equations are applied to the flow behind a bow shock under the formalism of a thin shock layer. Comparison of this version of the theory with Direct Simulation Monte Carlo calculations of flows about a flat plate at finite attack angle has lent support to the approach as a useful extension of the continuum model for studying translational nonequilibrium in the shock layer. This paper reassesses the physical basis and limitations of the development with additional calculations and comparisons. The streamline correlation principle, which allows transformation of the 13-moment based system to one based on the Navier-Stokes equations, is extended to a three-dimensional formulation. The development yields a strip theory for planar lifting surfaces at finite incidences. Examples reveal that the lift-to-drag ratio is little influenced by planform geometry and varies with altitudes according to a 'bridging function' determined by correlated two-dimensional calculations. Author

A91-21744
A THREE-DIMENSIONAL EULER CODE FOR CALCULATING FLOW FIELDS IN CENTRIFUGAL COMPRESSOR DIFFUSERS
INGOLF TEIPEL and ALEXANDER WIEDERMANN (Hannover, Universitaet, Hanover, Federal Republic of Germany) (CTAC-89 - International Conference on Computational Techniques and Applications, Brisbane, Australia, July 10-12, 1989) Computers and Fluids (ISSN 0045-7930), vol. 19, no. 1, 1991, p. 21-31. refs
Copyright

In order to avoid large computer running times and storage requirements, three-dimensional flow fields in turbomachines have been approximated by applying a general theory of Wu (1952) up to the present day. The handling of more complex flow problems has become possible with a reasonable effort. In this paper, a full three-dimensional code will be discussed which replaces the earlier quasi-three-dimensional approach. The code has been implemented on a conventional CYBER 990 and a CRAY-XMP. The running times of both computers will be compared to measure the effect of vectorization of the present FORTRAN code. Here the results obtained with the new three-dimensional time marching procedure are compared with those obtained with the earlier method. The present code prove to be a very efficient tool for solving three-dimensional flow fields in high-pressure-ratio centrifugal compressor diffusers. Author

A91-21748* Cincinnati Univ., OH.
INVISCID STEADY/UNSTEADY FLOW CALCULATIONS
H. S. PORDAL, P. K. KHOSLA, and S. G. RUBIN (Cincinnati, University, OH) (CTAC-89 - International Conference on Computational Techniques and Applications, Brisbane, Australia, July 10-12, 1989) Computers and Fluids (ISSN 0045-7930), vol. 19, no. 1, 1991, p. 93-118. refs
(Contract NAG3-716; F49620-85-C-0027)
Copyright

The solution of the Euler equations using a flux splitting procedure is considered for low subsonic to high supersonic flows. Steady and unsteady, internal and external flow fields, are

computed. For transient flows, a direct sparse matrix solver is applied to compute the flow field at each instant of time. Oscillation free normal and oblique shocks are captured. Unstart and restart of a simplified two-dimensional inlet is investigated. Author

A91-21879
ANALYSIS OF RAREFIED GAS FLOW NEAR A CRITICAL POINT [ANALIZ POTOKA RAZREZHENNOGO GAZA VBLIZI KRITICHESKOI TOCHKI]
E. M. SHAKHOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 30, Nov. 1990, p. 1744-1749. In Russian.
Copyright

A quasi-one-dimensional kinetic model is proposed which describes flow in the wall layer near a cold body. The model kinetic equation is used to solve the problem of heat transfer at the front critical point for the two-dimensional and axisymmetric cases. The numerical results obtained are compared with the available data. V.L.

A91-21940
MAXIMUM-RATE DECELERATION OF AN OBJECT DURING CONTROLLED MOTION UNDER THE EFFECT OF AERODYNAMIC DRAG AND GRAVITY FORCES [MAKSIMAL'NO BYSTROE TORMOZHENIE OB'EKTA, OSUSHCHESTVLIAIUSHCHEGO UPRAVLIAEMOE DVIZHENIE POD DEISTVIEM SIL AERODINAMICHESKOGO SOPROTIVLENIIA I TIAZHESTI]
B. E. FEDUNOV Prikladnaia Matematika i Mekhanika (ISSN 0032-8235), vol. 54, Sept.-Oct. 1990, p. 737-744. In Russian.
Copyright

The controlled motions of objects in the atmosphere due to aerodynamic drag and gravity forces are examined with reference to the model problem of the effect of these forces on the deceleration rate of an object in an exponential atmosphere. Rate-optimized control synthesis is developed for a class of objects whose aerodynamic drag can be characterized by a single force proportional to the product of object velocity and the atmosphere density at a given height. The optimal synthesis procedure can be simplified by introducing a certain level of significance for the control. V.L.

A91-21979
MACROSCOPIC MODEL OF VIBRATIONAL RELAXATION IN HEAT TRANSFER PROBLEMS FOR SUPERSONIC FLOW PAST HARD BODIES [MAKROSKOPICHESKAIA MODEL' KOLEBATEL'NOI RELAKSATSII V ZADACHAKH TEPLOPEREDACHI PRI SVERKHZVUKOVOM OBTEKANII TVERDYKH TEL]
V. M. DOROSHENKO, N. N. KUDRIAVTSEV, and V. V. SMETANIN (Moskovskii Fiziko-Tekhnicheskii Institut, Dolgoprudny, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 28, Sept.-Oct. 1990, p. 952-959. In Russian. refs
Copyright

For the case of heat transfer in a boundary layer near a body in the path of flow of a dissociated gas, an efficient method is proposed for considering the relaxation of vibrationally excited molecules formed as a result of atomic recombination. With reference to the nitrogen molecules, it is shown that a strong positive dependence of the vibrational-translational relaxation rate on the gas temperature makes it possible to take account of heat transfer associated with the vibrational-translational relaxation of molecules under nonequilibrium conditions. The calculated results based on the macroscopic vibrational relaxation model proposed here are in good agreement with results based on a system of vibrational relaxation equations for the boundary layer over a wide range of flow conditions. V.L.

A91-22351#
A NEW METHOD FOR SUBSONIC LIFTING-SURFACE THEORY
ZHENHAO LI (Chinese Helicopter Research and Development Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, July 1990, p. A309-A314. In Chinese, with abstract in English.

A new method based on lifting-surface theory is presented for determining the load distributions on finite wings in subsonic flows. A spanwise strip and a classical chordwise series are used. The order of the Mangler-type doubly singular integral is exchanged in order to make the calculations analytical and simple. A segmented polynomial approximation for the integrand of the chordwise integral is deduced to evaluate the kernel function in a closed-form finite-sum manner, resulting a well behaved coefficient matrix. Analytical results are compared with experimental data and other methods; the computational efficiency is demonstrated. Author

A91-22367#
OPTIMIZATION OF MULTI-ELEMENT AIRFOILS FOR MAXIMUM LIFTS IN SEPARATED FLOW
JIANFA CAO and YANQING CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B313-B319. In Chinese, with abstract in English. refs

A theoretical method for optimizing multielement airfoils in separated flow is presented to determine the optimum location and deflection angle of flap or slat relative to the main component corresponding to the optimum C(Lmax). The maximum lift coefficient is taken as the objective function. This approach is used to calculate the maximum lift of the NLR 7301 airfoil and the GA(w)-1 airfoil. The optimum computations are carried out for the GA(w)-1 airfoil. The results of the calculations are in good agreement with the wind-tunnel testing results. Author

A91-22382#
FLOWFIELD COMPUTATION OF 2-C-D NOZZLE
BAISONG CHEN (Air Force PR China, 2nd Aerotechnology School, People's Republic of China) and DA WU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B396-B399. In Chinese, with abstract in English. refs

The flow-field equations of 2-C-D nozzle have been solved by a time-dependent finite difference method known as two-step MacCormack technique. The computational results of nozzle wall pressure distribution and thrust agree well with experimental data. A complicated shock system has been attained through the computation of exhaust flow field. Author

A91-22392#
A PRACTICAL METHOD FOR THE AERODYNAMIC CALCULATIONS OF BLUNT BODIES OF REVOLUTION
WEIQUAN ZHANG (Lanzhou Commercial Institute, People's Republic of China) Acta Armamentarii (ISSN 1000-1093), Aug. 1990, p. 42-50. In Chinese, with abstract in English. refs

The paper presents a method to obtain the pressure distributions on blunt bodies of revolution in the supersonic-speed range. The method consists basically of a modified Newtonian theory for the stagnation region in correlation with the second-order shock-expansion theory when the surface flow becomes supersonic. The present method provides some formulas for the aerodynamic coefficients. Author

A91-22476#
EFFECTS OF A FILLET ON THE FLOW PAST A WING-BODY JUNCTION
W. J. DEVENPORT, N. K. AGARWAL, M. B. DEWITZ, R. L. SIMPSON, and K. PODDAR (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2017-2024. Previously cited in issue 11, p. 1591, Accession no. A89-30498. refs
(Contract N00014-88-C-0291)
Copyright

A91-22477#
INVISCID ANALYSIS OF TWO-DIMENSIONAL AIRFOILS IN UNSTEADY MOTION USING CONFORMAL MAPPING
D. H. CHOI (Korea Advanced Institute of Science and Technology,

Seoul, Republic of Korea) and L. LANDWEBER AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2025-2033. refs
Copyright

Using a conformal mapping technique, a procedure for calculating the irrotational flow about a two-dimensional airfoil of arbitrary shape in unsteady motion is developed. The two-dimensional form with a sharp trailing edge is transformed into a unit circle by two successive transformations. The latter of the two is a modified version of the Gershgorin integral equation, which yields solutions much more accurate than those obtained with panel methods. The change in circulation around the airfoil due to unsteadiness is modeled by discrete vortices that are shed from the trailing edge and allowed to move freely with the local stream. The strength of these vortices is determined by the Kutta condition that, at each time step, the velocity be zero at the trailing edge in the circle plane. The procedure is efficient since the integral equation is solved only once. Numerical examples are presented for a sinusoidal heaving motion and for an impulsively started airfoil. Author

A91-22479#
VELOCITY FIELD OF AN AXISYMMETRIC PULSED, SUBSONIC AIR JET
KLAUS BREMHORST and PETER G. HOLLIS (Queensland, University, Brisbane, Australia) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2043-2049. refs
Copyright

Laser Doppler anemometer measurements in a fully pulsed, subsonic air jet with a significant no-flow period between pulses have been conducted and show much higher entrainment than steady or partially pulsed jets of the same mass flow. The mean centerline velocity decay is linearly related to the inverse of the effective distance from exit for some 50 diameters, but centerline velocity decay is much slower than for steady jets due to dominationi by the periodic component and its associated pressure field, which affects jet momentum. For larger distances, the decay changes to the steady jet rate. Reynolds stresses are considerably larger than for a steady jet and are considered to be responsible for the increased entrainment. Results are, except for a small increase in the constant of proportionality, consistent with Taylor's entrainment hypothesis. Phase averaged results through a cycle show the ratio of shear stress to turbulent kinetic energy to be in the range of 0.2-0.3 for the bulk of the flow. Author

A91-22481#
UNSTEADY SEPARATION OVER MANEUVERING BODIES
S. F. SHEN and TZUYIN WU (Cornell University, Ithaca, NY) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2059-2068. Previously cited in issue 20, p. 3344, Accession no. A88-48875. refs
(Contract AF-AFOSR-86-0328)
Copyright

A91-22483*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VORTICAL FLOW COMPUTATIONS ON SWEPT FLEXIBLE WINGS USING NAVIER-STOKES EQUATIONS
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2077-2084. Previously cited in issue 12, p. 1776, Accession no. A89-31362. refs
Copyright

A91-22491#
NUMERICAL SOLUTION OF THE EQUATION FOR A THIN AIRFOIL IN GROUND EFFECT
LAZAR DRAGOS (Bucuresti, Universitatea, Bucharest, Rumania) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2132-2134. refs
Copyright

An effort is made to integrate the thin-airfoil equation in ground effect, using Gauss-type quadrature formulas. Unlike classical methods, in which the thin airfoil is supplanted by a vortex distribution, the present method replaces the airfoil with a force distribution. The intensity of this distribution is determined in such a way that its effect of the fluid duplicates that of the wing. Numerical results are presented. O.C.

A91-22492#
OPTIMUM HYPERSONIC AIRFOIL WITH POWER LAW SHOCK WAVES
B. A. WAGNER AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2134-2136. refs
(Contract AF-AFOSR-88-0037)
Copyright

The present examination of the inviscid flowfield over a family of two-dimensional lifting surfaces uses hypersonic small-disturbance theory to treat not only convex but concave surfaces. On this basis, a wider class of lifting surfaces is constructed using the streamlines of the basic flowfield. Boundary layers are assumed to be thin and attached to the surface; the surfaces are considered to correspond to the lower compression surface of a two-dimensional wing. O.C.

A91-22497#
FLOW SEPARATION PATTERNS OVER AN F-14A AIRCRAFT WING
TSZE C. TAI (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 9 p. Research supported by the U.S. Navy. refs
(AIAA PAPER 90-0596)

Computational results of flow over an F-14A wing based on a thin-layer Navier-Stokes method are presented, and the resulting flow separation patterns are discussed. A zonal approach is employed that allows condensed grid for viscous calculations near the wing surface. The F-14A wing is fixed with a sweep angle of 20 degrees and travels at an altitude of 45,000 feet above sea level at Mach 0.6 and at sea level at Mach 0.1 with various angles of attack. These conditions, which yield a Reynolds number of 8.95 x 10 to the 6th, allow evaluation of the effect of Mach number on flow separation patterns with fixed Reynolds number. Massive flow separation occurs at Mach 0.6 at an angle of attack of 10 degrees. At Mach 0.1, with the same Reynolds number, the rear region massive separation is replaced by a moderate leading edge separation. As a consequence, the lift and drag values are far more stable at low speed as the angle of attack increases. Author

A91-22499*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A STEADYING EFFECT OF ACOUSTIC EXCITATION ON TRANSITORY STALL
K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Previously announced in STAR as N91-13420. refs
(AIAA PAPER 91-0043) Copyright

The effect of acoustic excitation on a class of separated flows with a transitional boundary layer at the point of separation is considered. Experimental results on the flow over airfoils, a two-dimensional backward-facing step, and through large angle conical diffusers are presented. In all cases, the separated flow undergoes large amplitude fluctuations, much of the energy being concentrated at unusually low frequencies. In each case, an appropriate high frequency acoustic excitation is found to be effective in reducing the fluctuations substantially. The effective excitation frequency scales on the initial boundary layer thickness and the effect is apparently achieved through acoustic tripping of the separating boundary layer. Author

A91-22511* Manchester Univ. (England).
THE INVISCID STABILITY OF SUPERSONIC FLOW PAST A SHARP CONE
PETER W. DUCK and STEPHEN J. SHAW (Manchester, Victoria University, England) Theoretical and Computational Fluid

Dynamics (ISSN 0935-4964), vol. 2, no. 3, 1990, p. 139-163. refs
(Contract NAS1-18605; SERC-GR/E/25702)
Copyright

The effects of lateral curvature on the development of supersonic laminar inviscid boundary-layer flow on a sharp cone with adiabatic wall conditions are investigated analytically, with a focus on the linear temporal inviscid stability properties. The derivation of the governing equations and of a 'triply generalized' inflexion condition is outlined, and numerical results for freestream Mach number 3.8 are presented in extensive graphs and characterized in detail. A third instability mode related to the viscous mode observed by Duck and Hall (1990) using triple-deck theory is detected and shown to be more unstable and to have larger growth rates than the second mode in some cases. It is found that the 'sonic' neutral mode is affected by the lateral curvature and becomes a supersonic neutral mode. T.K.

A91-22762#
THE INFLUENCES OF FORCED OSCILLATIONS TOWARD VORTEX-BREAKDOWN
YANQIU CHEN, ZHIYONG LU, and CHUN-HIAN LEE (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A505-A509. In Chinese, with abstract in English. refs

The experimental results on the effects of oscillating leading-edge vortex-flaps of a triangular wing on vortex breakdown are presented. The results reveal that forced oscillations can delay the breakdown of concentrated vortices, and large reversed-flow regions which originally appear at the upper surface of the fixed wing at high angles of attack would be suppressed to some extent, depending on the oscillation frequencies. As a consequence, the effects can be optimized by selecting proper oscillation frequencies. Author

A91-22763#
AF-2 ITERATION AND ITS PARALLEL ALGORITHM FOR TRANSONIC FLOW WITH LARGE DISTURBANCES IN FREESTREAM-DIRECTION AROUND AXISYMMETRIC BODIES AT ZERO ANGLE OF ATTACK
SAIJIN MIN, XIUYING LI (National University of Defence Technology, People's Republic of China), and SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A510-A514. In Chinese, with abstract in English. refs

The calculations of an AF-2 scheme are made by serial and parallel algorithms on a computer for solving axisymmetrical transonic potential equation with large disturbances in the freestream direction and small disturbance in the radial direction. By computations, the convergence of AF-2 is compared with that of SLOR, and the efficiency for parallel algorithm of AF-2 is compared with the efficiency for serial algorithm. Results indicate that AF-2 technique has led to a 3 to 7 fold improvement in convergence against SLOR, and the computation efficiency by the parallel algorithm of AF-2 is about 3 times higher than that by the serial algorithm of AF-2. Author

A91-22764#
CALCULATION OF UNSTEADY AERODYNAMIC LOADS ON WINGS WITH AN OSCILLATORY LEADING EDGE FLAP
LI YUAN, ZHIYONG LU (Beijing University of Aeronautics and Astronautics, People's Republic of China), and J. M. WU (Tennessee, University, Tullahoma) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A515-A520. In Chinese, with abstract in English. refs

The unsteady aerodynamic loads on wings with leading edge (LE) separation in inviscid incompressible flow are calculated using the vortex-lattice method. The calculated results of delta and double delta wings with oscillating LE flaps not only show influence upon aerodynamic response as a result of different oscillatory frequencies and hinge line swept-back angles, but also reveal the phenomena of aerodynamic lag and nonlinear interaction associated with unsteady vortex flows. Author

A91-22878*# Analytical Services and Materials, Inc., Hampton, VA.
FLUX-DIFFERENCE SPLIT SCHEME FOR TURBULENT TRANSPORT EQUATIONS
J. H. MORRISON (Analytical Services and Materials, Inc., Hampton, VA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 11 p. refs
(Contract NAS1-18599)
(AIAA PAPER 90-5251)

This paper describes a high accuracy upwind method to solve the mean compressible flow equations closed with two-equation turbulence models. A flux-difference splitting scheme is developed to compute the flowfield without introducing oscillations into the solution. A high-order accuracy scheme is used to predict both the mean flow variables and the turbulence variables. Results comparing two different two-equation turbulence models are presented for supersonic flow over a flat plate and a compressible, free shear-layer. The non-oscillatory behavior of the upwind scheme is demonstrated on the free shear-layer. Author

A91-22882*# High Technology Corp., Hampton, VA.
BOUNDARY LAYER RECEPTIVITY PHENOMENA IN THREE-DIMENSIONAL AND HIGH-SPEED BOUNDARY LAYERS
MEELAN CHOUDHARI (High Technology Corp., Hampton, VA) and CRAIG L. STREETT (NASA, Langley Research Center, Hampton, VA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 22 p. refs
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The process by which the boundary layer internalizes the environmental disturbances in the form of instability waves is known as the boundary-layer receptivity. The paper discusses the importance of receptivity in transition research. The receptivity scenario for three-dimensional and high-speed boundary layers is examined. It is found that, while receptivity mechanisms present in the low-speed case are also operative in these complex flows, certain uniquely 'compressible' receptivity mechanisms may come into play as well. Both numerical, and where convenient, asymptotic procedures are utilized to develop quantitative predictions of the localized generation of a variety of instability types (Tollmien-Schlichting, inflectional, higher modes, crossflow vortices) in boundary layer flows relevant to the National Aero-Space Plane (NASP). Author

A91-22883#
SIMPLIFIED MODELING OF BLUNT NOSE EFFECTS ON VEHICLE FLOW FIELDS
J. W. HANEY and B. A. MILLER (Rockwell International Corp., Downey, CA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 6 p. refs
(AIAA PAPER 90-5259) Copyright

A simplified method has been developed to predict the impact of nose bluntness on the velocity distributions for axisymmetric vehicles. The method makes use of both wind tunnel and computational fluid dynamics to develop the data base for correlating local velocities. Author

A91-22893#
THE INVESTIGATION OF THE HYPERSONIC VEHICLE AEROTHERMODYNAMICS
V. N. GUSEV (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 25 p. refs
(AIAA PAPER 90-5271) Copyright

A numerical-experiment approach is described which makes possible the efficient investigation of hypersonic flow about vehicles under conditions ranging from continuum to free molecular flow. A method for introducing corrections to aerodynamic characteristics

for vehicles with perfect aerodynamic shapes is considered. Particular attention is given to the calculation of intense heating experienced by the hypersonic vehicle in a descent trajectory. B.J.

A91-23095#
CALCULATIONS ON TOTAL TEMPERATURE AND PRESSURE IN HYPERSONIC AIR FLOW
SHAOQING WANG (31st Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1990, p. 29-33. In Chinese, with abstract in English.

Total temperature and total pressure of a gas flow in chemical equilibrium, isentropy with variable composition and specific heat at Ma = 0 to about 7.0 and H = 0 to about 40 km are calculated. The results are compared with those calculated with an aerodynamic function method, a modifying coefficient method and the method issued by the R-R company. In this paper, the variations of total temperature and pressure with Ma and H are presented. The results show that if Ma is greater than 3.00, the calculation results by the thermodynamic method and aerodynamic function method are remarkably different. For example, at Ma = 6.50, the relative deviation of total temperature exceeds 14 percent, and that of total pressure is greater than 26 percent. Author

A91-23186
COMPUTATION OF THREE-DIMENSIONAL SUBSONIC FLOWS IN DUCTS USING THE PNS APPROACH
A. R. ASLAN and R. GRUNDMANN (Institut Von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, Dec. 1990, p. 373-380. refs
(Contract BMVG-T/RF42/G022/G1412)
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The steady laminar incompressible three-dimensional flow field in ducts of constant square cross section is analyzed. It is found that an a priori inviscid pressure distribution must be included in the analysis in order to take upstream effects into account. The inviscid pressure distribution is computed by solving Laplace's equation by a finite element method. Detailed comparison of the computations of the S-bend geometry with experimental data are presented, both with and without the inviscid pressure distribution. C.D.

A91-23189
LINEAR STABILITY ANALYSIS OF MEASURED NEAR-WAKE PROFILES FOR A FLAT PLATE IN LONGITUDINAL FLOW [LINEARE STABILITAETSANALYSE GEMESSENER NAHER NACHLAUFPROFILE EINER LAENGS ANGESTROEMTEN EBENEN PLATTE]
W. ALTHAUS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, Dec. 1990, p. 400-405. In German. refs
Copyright

The supersonic wake generated by a flat plate can exhibit a turbulent or vortical structure depending on the nature of the surface of the plate. If the roughness of the surface, varied by pasting sandpaper onto it, exceeds a critical value, and if the sandpaper ends at a certain distance from the trailing edge, the wake has a vortical structure; otherwise it is turbulent. Linear local stability analysis of measured velocity profiles of the near wake, together with a global resonance criterion, gives good agreement between the measured and calculated Strouhal numbers for subsonic freestream Mach numbers. The underlying physical model of the analysis can explain some aspects of the phenomenon investigated. Spatial development of the wake profiles is necessary for the flow to become globally unstable. Surface roughness seems to be necessary to reach the required minimum length of the local absolute unstable region. Author

A91-23550
AN INVESTIGATION OF SUPERSONIC OSCILLATORY CAVITY FLOWS DRIVEN BY THICK SHEAR LAYERS
X. ZHANG and J. A. EDWARDS (Cambridge, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 94, Dec. 1990, p. 355-364. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

This study forms part of a theoretical and experimental investigation into single and multiple cavity flow and it is indicated that the results for single cavities will form the basis for understanding work on multiple cavities. Time averaged and unsteady results of an experimental study of the fluid dynamic characteristics of supersonic cavity flows driven by thick shear layers are presented. Changes in the time-mean and the time-dependent flow characteristics at different flow conditions are discussed. The experimental time-dependent results are compared with existing theoretical analyses of the frequencies. For one of these oscillation characteristic types (longitudinal oscillation) an existing theoretical description is improved with a modified phase relation. R.E.P.

A91-23639#
COMPUTATIONAL FLUID DYNAMIC APPLICATIONS FOR JET PROPULSION SYSTEM INTEGRATION
R. H. TINDELL (Grumman Corp., Bethpage, NY) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 40-50. refs
(ASME PAPER 90-GT-343) Copyright

Various CFD codes are presently used for the prediction of performance of such propulsion system elements as inlets and nozzles. Attention is given to the supersonic flow Euler analysis of an inlet-approach flow field, to clarify an apparent discrepancy between wind tunnel and flight data results. Also noted are the results obtainable with calculations for low-speed inlet performance at indidence, as well as for the more complex inlet flow phenomena obtained at high angles of attack with an approach combining a panel method with a Navier-Stokes code. Propulsion integration is treated in the form of nozzle-afterbody calculations using a Navier-Stokes code and a more economical equivalent-body-of-revolution technique. O.C.

A91-23640*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRFRAME/PROPULSION INTEGRATION AT TRANSONIC SPEEDS
W. P. HENDERSON (NASA, Langley Research Center, Hampton, VA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 51-59. refs
(ASME PAPER 90-GT-338) Copyright

A significant level of research is ongoing at NASA's Langley Research center on integrating the propulsion system with the aircraft. This program has included nacelle/pylon/wing integration for turbofan transports, propeller/nacelle/wing integration for turboprop transports, and nozzle/afterbody/empennage integration for high-performance aircraft. The studies included in this paper focus more specifically on pylon shaping and nacelle bypass ratio studies for turbofan transports, nacelle and wing contouring, and propeller location effects for turboprop transports, empennage effects, and thrust vectoring for high-performance aircraft. The studies were primarily conducted in NASA Langley's 16-Foot Transonic Tunnel at Mach numbers up to 1.20. Author

A91-23656#
EXPERIMENTAL STUDY OF THE THREE-DIMENSIONAL FLOW FIELD IN A TURBINE STATOR PRECEDED BY A FULL STAGE
E. BOLETIS and C. H. SIEVERDING (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 113, Jan. 1991, p. 1-9. refs
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Results are reported of an experimental investigation of the flow through a low aspect ratio turbine stator with inlet conditions generated by an upstream stage. The inlet flow conditions to a turbine stator preceded by a full stage are considerably different

from those generated in isolated cascades. In particular, the shape of the inlet flow angle and total pressure distributions are affected by radial free-stream gradients and rotor secondary and clearance flows. The flow field in the stator blade row is strongly influenced by the combined action of the rotor clearance flow and the free-stream total pressure gradient. They augment the effects of the radial static pressure gradient generated within the blade row, causing a significant radial migration of low-momentum boundary layer material along the rear suction side. Downstream of the cascade the rotor tip clearance effects influence the angle distribution over the entire upper span. C.D.

A91-23842
AN EXPERIMENTAL STUDY OF THE EVOLUTION OF HARMONIC PERTURBATIONS IN A BOUNDARY LAYER ON A FLAT PLATE AT MACH 4 [EKSPERIMENTAL'NOE ISSLEDOVANIE RAZVITIIA GARMONICHESKIKH VOZMUSHCHENII V POGRANICHNOM SLOE PLOSKOI PLASTINY PRI CHISLE MAKHA M = 4]
A. D. KOSINOV, A. A. MASLOV, and S. G. SHEVEL'KOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1990, p. 54-58. In Russian. refs
Copyright

The evolution of three-dimensional wave packets introduced artificially into a boundary layer is investigated experimentally. Measurements were carried out by hot-wire anemometry in a boundary layer on a flat plate at Mach 4. Artificial perturbations were introduced into the boundary layer by using an electric discharge. A Fourier analysis of the experimental results has yielded the wave characteristics of the plane waves. The composition of the perturbations is analyzed, and the types of perturbations that are most likely to cause a loss of stability are identified. V.L.

A91-23845
EFFECT OF SURFACE TEMPERATURE ON THE STABILITY OF THE ATTACHMENT LINE BOUNDARY LAYER OF A SWEPT WING [VLIIANIE TEMPERATURY POVERKHNOSTI NA USTOICHIVOST' POGRANICHNOGO SLOIA NA LINII PRISOEDINENIIA SKOL'ZIASHCHEGO KRYLA]
A. V. KAZAKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1990, p. 78-82. In Russian. refs
Copyright

The effect of surface temperature on the stability characteristics of laminar flow of a viscous heat-conducting gas at the leading edge of a swept wing is investigated analytically. It is found that an increase in surface temperature leads to a rapid decrease in the Reynolds number of stability loss. An increase in the Mach number, on the contrary, stabilizes flow at the attachment line, although the Reynolds number of stability loss increases only slightly. V.L.

A91-23848
A STUDY OF FLOW STRUCTURE IN NOZZLES WITH A CONSTANT-HEIGHT SECTION IN THE THROAT REGION [ISSLEDOVANIE STRUKTURY TECHENIIA V SOPLAKH S UCHASTKOM POSTOIANNOI VYSOTY V OBLASTI MINIMAL'NOGO SECHENIIA]
O. A. VASIL'EV, S. N. MININ, and A. V. SHIPOVSKIKH Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Nov.-Dec. 1990, p. 160-166. In Russian. refs
Copyright

Results of an analytical and experimental study of flow structure in plane nozzles with a constant-height section in the throat area are reported. The nozzle used in the experiments consisted of two shaped duralumin plates 1500 mm wide. The effect of the longitudinal and transverse deflections of the nozzle vanes on the parameters of transonic and supersonic flows is discussed. V.L.

A91-23903
EFFECT OF THE INITIAL FLOW CONDITIONS ON THE AERODYNAMIC AND ACOUSTIC CHARACTERISTICS OF TURBULENT JETS [VLIIANIE NACHAL'NYKH USLOVII ISTECHENIIA NA AERODINAMICHESKIE I AKUSTICHESKIE KHARAKTERISTIKI TURBULENTNYKH STRUI]
E. V. VLASOV, A. S. GINEVSKII, and R. K. KARAVOSOV IN: Mechanics of nonuniform and turbulent flows. Moscow, Izdatel'stvo Nauka, 1989, p. 26-34. In Russian. refs
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The effect of acoustic and vibrational perturbations on the aerodynamic characteristics of jets is investigated theoretically and experimentally for laminar and turbulent boundary layers of varying initial thickness. It is shown that, depending on the excitation frequency and amplitude, the acoustic and vibrational excitation of turbulent jets may either intensify or weaken mixing. The introduction of artificially generated acoustic or vibrational perturbations can thus be used as an efficient control method for turbulent jets. V.L.

A91-23913
TURBULENT THREE-DIMENSIONAL SEPARATED FLOWS IN A SUPERSONIC STREAM NEAR OBSTACLES AT THE EDGE OF DIHEDRAL CORNERS [TURBULENTNYE TREKHMERNYE OTRYVNYE TECHENIIA V SVERKHZVUKOVOM POTOKE VBLIZI PREPIATSTVII NA REBRAKH DVUGRANNYKH UGLOV]
A. I. GLAGOLEV, A. I. ZUBKOV, B. E. LIAGUSHIN, and IU. A. PANOV IN: Mechanics of nonuniform and turbulent flows. Moscow, Izdatel'stvo Nauka, 1989, p. 194-201. In Russian.
Copyright

Supersonic flow past three-dimensional obstacles located at the edge of acute and obtuse dihedral corners were investigated experimentally in a wind tunnel at Mach 3 using dihedral-corner models consisting of two tapered plates. Replaceable cylinders of varying length and diameter were mounted at the edge. It is found that three-dimensional separated flows forming in front of obstacles at the edge of external dihedral corners are characterized by a decrease in the separation zone length with an increase of the external angle, disappearance of a local supersonic region in the vicinity of the edge, and a decrease in the critical pressure drop at the edge that leads to flow separation. V.L.

A91-24115#
DOUBLE LINEARIZATION THEORY FOR A ROTATING SUBSONIC ANNULAR CASCADE OF OSCILLATING BLADES. I - MATHEMATICAL EXPRESSIONS OF DISTURBANCE FLOW FIELD. II - NUMERICAL STUDY OF UNSTEADY AERODYNAMIC FORCES
KAZUHIKO TOSHIMITSU, MASANOBU NAMBA (Kyushu University, Fukuoka, Japan), and PING LI Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 50, June 1990, p. 161-199. refs

Mathematical expressions for steady and unsteady disturbance flow fields are obtained on the basis of the double linearization theory. A numerical study of unsteady aerodynamic forces is carried out. Three-dimensional effects in pure n- and s-wise bending and in pure torsional vibrations are investigated. K.K.

A91-24152#
SOLUTION OF EULER EQUATIONS TO 2-D AND AXISYMMETRIC COMPRESSIBLE FLOWS USING CONFORMAL MAPPING COORDINATES
MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 371-378. In Chinese, with abstract in English. refs

Conformal mapping is used here to transform two-dimensional and axisymmetric Euler equations. It is found that the Euler equations can be cast in quasi-conservative form with source terms containing no unknown derivatives, and that the only unknown velocity components are those aligned with the direction of curvilinear coordinates in transformed equations. The derived equations are almost as simple as those in Cartesian systems. As

examples, the equations are used to compute two-dimensional and axisymmetric flows past arbitrary airfoils and bodies of revolution. The results show that the method has good accuracy and shock resolution. C.D.

A91-24154#
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR MULTIPLE OSCILLATING AIRFOIL
QIN E and FENGWEI LI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 388-397. In Chinese, with abstract in English. refs

Inviscid, unsteady transonic flows over the NACA 0012 airfoil for sinusoidal pitching oscillations about the midchord were calculated using a finite-difference analog of the Euler equations. An extension of the unsteady transonic flow calculations to include perpendicular and horizontal oscillations and the superposition of pitch and translations is developed. In this method the grid motion together with the airfoil and the boundary conditions in infinity and on the surface of the airfoil are exactly satisfied, and the full field is covered with a fewer number of grids having a total of about 600 nodes. Author

A91-24155#
A METHOD FOR CALCULATING THE AERODYNAMIC FORCES OF ELLIPTICAL CIRCULATION CONTROL AIRFOILS
MAO SUN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 398-403. In Chinese, with abstract in English. refs

This paper presents a method for calculating the aerodynamic forces of elliptical circulation control airfoils by combining the boundary layer calculation and potential flow calculation. The effect of the separated wake on the potential flow is included using the discrete vortex method. Nascent vortices are introduced into the flow from the separation points on the upper and lower surface of the airfoil to model the separated vortex sheets. Only the vortices in the near wake are allowed to move freely and the vortices in the far wake are assumed to move with the freestream velocity. The effect of the boundary layer upstream of the jet exit on the jet development is neglected. These simplifications make the method very efficient. Good agreement is found between calculated and experimental results for the separation points and pressure distributions before the separation points and for lift coefficient vs. momentum coefficient. C.D.

A91-24156#
THE EFFECTS OF CANARD POSITION AERODYNAMIC CHARACTERISTICS OF FORWARD-SWEPT WING
BINQIAN ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) and B. LASCHKA (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 404-409. In Chinese, with abstract in English. refs

Based on the results of aerodynamic forces measurements, oil visualization and vortex measurement from wind tunnel testing, the effect of canard position on the aerodynamic characteristics of canard-forward swept wing configuration is investigated. The results show that the effect of canard position on the aerodynamic characteristics is noticeable. The improvements of aerodynamic characteristics for the canard-forward-swept wing configuration at high angles of attack depend on the relative location of the wing nose vortex ad the canard nose vortex and their interaction. Proper arrangements of the geometry of the wing and the canard and their relative position are proposed. A double forward-swept wing configuration is also discussed. Author

A91-24157#
A GREEN'S FUNCTION METHOD FOR CALCULATING THE TRANSONIC PRESSURE DISTRIBUTION OF WING
KAI WU and QIANGANG LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 410-416. In Chinese, with abstract in English. refs

A Green's Function Method for solving the steady nonlinear three-dimensional potential equation is proposed. The Green's theorem is used to transform the partial different equation to an integral equation. The integral equation is discretized by finite element and finite different methods. The resulting nonlinear simultaneous equations are solved by relaxation-interation methods. The influence coefficients represented by volume integrals are transformed to surface integrals by using the Gaussian theorem, so the analytical forms of these coefficients can be obtained. The results of the present method are in good agreement with those of finite difference method. Author

A91-24162#
CURVED VORTEX ELEMENTS FOR NUMERICAL WAKE MODELING
WUJIANG LOU and SHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 459-463. In Chinese, with abstract in English.

Connecting two vortex end points to form a vortex segment and evaluating its contribution to the induced velocity at an arbitrary point is the key element in wake numerical analysis. The conventional straight line vortex element (SLVE) is unable to produce high accuracy evaluation in the case of a complex wake structure, such as a helicopter rotor wake, where a substitution for the SLVE is essentially needed. This paper covers the derivation and development of CVEC (curved vortex element on circular arcs) and CVEP (curved vortex element on parabolic arcs) and conscientiously prepared numerical tests to show their high accuracy and efficiency. Both CVEC and CVEP are recommended for use in advanced wake modeling. Author

A91-24163#
THE METHOD FOR EXTENDING THE RANGE OF ATTACK ANGLE AND BLOCKAGE IN TRANSONIC WIND TUNNEL TESTING - USING LOW SUPERSONIC NOZZLE INSTEAD OF SONIC NOZZLE
CHANGHAI ZHOU (Shenyang Aerodynamics Research Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 464-467. In Chinese, with abstract in English.

Instead of the sonic nozzle, low supersonic nozzles have been utilized to solve the choking problem in transonic wind tunnel testing at high angle of attack and high blockage. The low supersonic nozzles can produce steady low supersonic flowfield with satisfactory quality, double the allowable angles of attack and blockage limits, and fill in the gaps in Mach-number/attack-angle range. Model test results from a small wind tunnel are in good agreement with the data obtained in large wind tunnel for a model of the same scale. Author

A91-24164#
NUMERICAL COMPUTATION OF SHOCK IN THE FRONT OF BLUNT BODY
HUI ZHANG and WEICHENG FAN (University of Science and Technology of China, Hefei, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 468-472. In Chinese, with abstract in English.

The shock problem is studied by direct solving N-S equations. Explorations are made of whether supersonic and transonic flows can be solved by direct solution of N-S equations, and how to do it. New approaches to treatment of viscous term, construction of pressure correction equation for compressible flow, and numerical methods are proposed and adopted in the paper. Computational results obtained are basically reasonable. Author

A91-24167#
CALCULATION OF TRANSONIC NOZZLE FLOW
DINGYOU FANG (National University of Defence Technology, People's Republic of China) Acta Aerodynamica Sinica (ISSN

0258-1825), vol. 8, Dec. 1990, p. 486-490. In Chinese, with abstract in English.

The time-dependent method is applied to the calculation of transonic nozzle flow in this paper. The transonic nozzle is computed by solving the conservation and nonconservation governing equations with uniform integration step size in the full flowfield and local integration step size, and by the corrected dashpot method. The computational results show that the convergence rate of the numerical solution with local integration step size is the fastest among these computations. The convergence rate with uniform integration step size for nonconservation equations is faster than that for conservation equations, and the corrected dashpot method with optimizing damping factor and time interval is a better method for computing transonic nozzle flow. Author

A91-24168#
VISCOUS-INVISCID INTERACTIVE SEMI-INVERSE CODE FOR THREE DIMENSIONAL TRANSONIC FLOW
GONGBI WEN, XIAOYI HE, and WANGYI WU (Beijing University, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 491-497. In Chinese, with abstract in English. refs

A version of viscous-inviscid interactive semiinverse code for three-dimensional transonic flow is proposed. Inverse integral method is used for compressible turbulent boundary layer. It is proved that with external streamline angle alpha and 'incompressible' shape H choice of inputs the integral boundary layer equations are always hyperbolic in the transonic regime. The inviscid calculation is performed using FL027 which is the full potential code. Viscous-inviscid interactive solution which agreed reasonably well with experiments in small attack angle is obtained for the case of small separated region. Author

N91-15125*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC INTERNAL PERFORMANCE OF AN AXISYMMETRIC NOZZLE WITH MULTIAXIS THRUST-VECTORING CAPABILITY
GEORGE T. CARSON, JR. and FRANCIS J. CAPONE Washington Feb. 1991 77 p
(NASA-TM-4237; L-16809; NAS 1.15:4237) Avail: NTIS HC/MF A05 CSCL 01A

An investigation was conducted in the static test facility of the Langley 16 Foot Transonic Tunnel in order to determine the internal performance characteristics of a multiaxis thrust vectoring axisymmetric nozzle. Thrust vectoring for this nozzle was achieved by deflection of only the divergent section of this nozzle. The effects of nozzle power setting and divergent flap length were studied at nozzle deflection angles of 0 to 30 at nozzle pressure ratios up to 8.0. Author

N91-15126*# Brown Univ., Providence, RI. Div. of Engineering.
PARAMETER IDENTIFICATION FOR NONLINEAR AERODYNAMIC SYSTEMS Annual Report, 23 Oct. 1989 - 22 Oct. 1990
ALLAN E. PEARSON 19 Nov. 1990 59 p
(Contract NAG1-1065)
(NASA-CR-187410; NAS 1.26:187410; SATR-2; ATR-1) Avail: NTIS HC/MF A04 CSCL 01A

Parameter identification for nonlinear aerodynamic systems is examined. It is presumed that the underlying model can be arranged into an input/output (I/O) differential operator equation of a generic form. The algorithm estimation is especially efficient since the equation error can be integrated exactly given any I/O pair to obtain an algebraic function of the parameters. The algorithm for parameter identification was extended to the order determination problem for linear differential system. The degeneracy in a least squares estimate caused by feedback was addressed. A method of frequency analysis for determining the transfer function G(j omega) from transient I/O data was formulated using complex valued Fourier based modulating functions in contrast with the trigonometric modulating functions for the parameter estimation problem. A simulation result of applying the algorithm is given under noise-free conditions for a system with a low pass transfer function. B.G.

N91-15127 Air Force Inst. of Tech., Wright-Patterson AFB, OH.
NUMERICAL SOLUTIONS FOR A CYLINDRICAL LASER DIFFUSER FLOW-FIELD Ph.D. Thesis
JAMES ANDREW HORKOVICH 1990 394 p
Avail: Univ. Microfilms Order No. DA9027995

Numerical solution to the diffusion of a supersonic flow through a cylindrical laser diffuser is approached by incorporating a modified two-layer Cebici-Smith algebraic eddy viscosity turbulence model into the compressible Navier-Stokes equations. The standard algebraic constants are made functions of the local adverse pressure gradient based on experimental values obtained in the research of Jobe, Hankey, Laderman, Sturek, and Waltrup and Schetz. This modification allows solution of the Navier-Stokes equations by MacCormack's time splitting explicit numerical scheme for selected experimental flow conditions. This effort represents the first full Navier-Stokes solution that has accurately simulated the viscous-inviscid interactions present in a supersonic axisymmetric diffuser. The experimental tests used as a basis for the computational solutions were conducted at a diffuser entrance unit Reynolds number of 1.6 million per foot. Computations were performed for diffuser exit pressure representing 60 and 47 percent of normal shock recovery pressure. When the turbulence model was properly modified to accommodate the physics of flows with strong adverse pressure gradients, the numerical solution successfully reproduced all of the essential flow features including boundary layers, location, and size of wall separation regions, location of the core flow normal shock, and the persistence of source nozzle flow interactions through several streamwise turnback shocks. Convergence to stable numerical solutions was not achieved using the basic Cebici-Smith models. The required modifications to the basic Cebici-Smith two-layer algebraic eddy viscosity turbulence model are extremely sensitive to the von Karman universal mixing length constant, the sublayer thickness parameter, the Clauser outer region constant, and to the downstream location in the diffuser duct at which these modifications are implemented. Dissert. Abstr.

N91-15128*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FLOWFIELD OF A LIFTING HOVERING ROTOR: A NAVIER-STOKES SIMULATION
G. R. SRINIVASAN, J. D. BAEDER, S. OBAYASHI (MCAT Inst., Moffett Field, CA.), and W. J. MCCROSKEY Aug. 1990 26 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990 Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA
(NASA-TM-102862; A-90274; NAS 1.15:102862) Avail: NTIS HC/MF A03 CSCL 01A

The viscous, three-dimensional flowfield of a lifting helicopter rotor in hover is calculated by using an upwind, implicit, finite-difference numerical method for solving the thin layer Navier-Stokes equations. The induced effects of the wake, including the interaction of tip vortices with successive blades, are calculated as a part of the overall flowfield solution without using any ad hoc wake models. Comparison of the numerical results for the subsonic and transonic conditions show good agreement with the experimental data and with the previously published Navier-Stokes calculations using a simple wake model. Some comparisons with Euler calculations are also presented, along with some discussions of the grid refinement studies. Author

N91-15129*# Stanford Univ., CA. Dept. of Mechanical Engineering.
DIRECT NUMERICAL SIMULATIONS OF A PLANE COMPRESSIBLE WAKE: STABILITY, VORTICITY DYNAMICS, AND TOPOLOGY
JACQUELINE H. CHEN, BRIAN J. CANTWELL, and NAGI N. MANSOUR Nov. 1989 180 p

(Contract DE-AC04-76DR-00789)
(NASA-CR-187737; NAS 1.26:187737; DE90-007934;
SAND-90-8201) Avail: NTIS HC/MF A09 CSCL 01A

Recent interest in supersonic combustion and problems of transatmospheric flight has prompted renewed research efforts in laminar-turbulent free shear flow transition. In the present work, linear stability theory and direct numerical simulations are used to study the effect of Mach number on the linear, nonlinear, and three-dimensional aspects of transition in a plane compressible wake. Direct numerical simulations are also used to study the sensitivity of a compressible wake to: (1) phase effects, and (2) two- and three-dimensional subharmonics. A linear stability analysis shows that the influence of increasing Mach number is stabilizing, resulting in reduced growth rates for both antisymmetric and symmetric modes of the wake. This reduction is due to baroclinic and dilatational effects as revealed from the linear eigenfunctions. For both low and high Mach numbers, the least stable wave is a two-dimensional antisymmetric mode aligned with the stream-wise direction. Three-dimensional simulations were performed to study the effect of phase angle between a fundamental and a pair of oblique waves on the development of the large-scale structures in a wake. Finally, the topology of the computed velocity, vorticity, and pressure gradient fields is determined using a generalized three-dimensional critical point theory. DOE

N91-15130 ESDU International Ltd., London (England).
AIRFRAME-INDUCED UPWASH AT SUBSONIC SPEEDS Abstract Only
Oct. 1990 38 p
(ESDU-90020; ISBN-0-85679-746-4; ISSN-0141-397X) Avail: ESDU

This Data Item 90020, an addition to the Aerodynamic Sub-series, provides a simple theoretically-based method for predicting the upwash at any point in the flow field ahead of the wing. The method, based on the Yaggy-Rogallo method, combines contributions from those airframe components that are planar lifting with contributions from the body-like essentially non-lifting components, with allowance for interference. For lifting surfaces a graphical method was developed from a correlation of a large number of calculations using the original approach but with spanwise loadings from lifting-surface theory. A correction factor to obtain results out of the plane of the surface was developed using a single swept horseshoe vortex. This approach greatly reduces the work required to calculate wing upwash. The method for body-like components uses an analytical integration of an equivalent axisymmetric body by dividing it into cross-sectional segments whose sides are approximately linear. For both types of components the first-order effects of compressibility are taken into account. The method has a wide range of applications with wing-body combinations. For use with ESDU 89047 to predict normal force and moments on an inclined propeller an effective angle of attack is devised. The method was compared with test data for upwash due to isolated nacelles, upwash induced at the propeller plane for a number of wing-body-nacelle combinations, and upwash at a noseboom-mounted vane on a combat aircraft. The agreement between predictions and test results for Mach numbers up to critical is good and is discussed in detail. Two worked examples illustrate the use of the method. Author

N91-15131 ESDU International Ltd., London (England).
PERFORMANCE OF CONICAL DIFFUSERS IN SUBSONIC COMPRESSIBLE FLOW Abstract Only
Nov. 1990 41 p
(ESDU-90025; ISBN-0-85679-751-0; ISSN-0141-4011) Avail: ESDU

This Data Item 90025, an addition to the Fluid Mechanics, Internal Flow Sub-series, gives performance maps for straight axis diffusers with a sharp transition from an inlet pipe with naturally-developing flow. They apply for an inlet Reynolds number (based on pipe diameter) of one million. They plot static pressure recovery against diffuser area ratio (inlet/outlet) and length ratio (length/inlet radius) and each applies to a specific value of inlet Mach number (from 0.2 to 0.8) and a limited range of inlet pipe length/diameter ratios (from 0 to 35.5). Shown on each map are curves of optimum performance for either given length ratio or given area ratio. The maps, whose use is illustrated by two worked examples, can be applied to determine the performance of given design or to design an optimum diffuser. An approximate method is suggested for deriving the total head loss from the static pressure recovery. Various other influences on diffuser performance are discussed and illustrated with sketches for specific cases. They include Reynolds number variation, inlet turbulence intensity, inlet velocity profile shape, upstream shock wave/boundary layer interaction, the approach to choking Mach number, fairing the inlet/diffuser junction, and fitting a tailpipe. ESDU

N91-15132 ESDU International Ltd., London (England).
AN INTRODUCTION TO AIRCRAFT EXCRESCENCE DRAG Abstract Only
Nov. 1990 14 p
(ESDU-90029; ISBN-0-85679-755-3; ISSN-0141-397X) Avail: ESDU

This Data Item 90029, an addition to the Aerodynamics Sub-series, provides information to assist in the application of the group of ESDU data on the prediction of the drag due to such excrescences as grooves, ridges and steps, rivets, and cylinders and stub wings immersed in the boundary layer. Those data were obtained from wind tunnel tests of an idealized condition in which the excrescence was mounted on a flat plate with no pressure gradient, and the application of such data in the real aircraft situation is considered. Corrections are required for the effect of pressure gradient and flow orientation. The pressure gradient correction on a lifting surface is a magnification factor (although it can be less than unity) and its estimation in incompressible two-dimensional flow is discussed; its variation with the boundary layer parameters on an airfoil is illustrated graphically. The analysis is extended to compressible flow and reference is made to the prediction methods in ESDU 87004. The treatment of an excrescence only partially immersed in the boundary layer is also considered, and recommendations are made for the case of excrescences on non-lifting components. The effect of flow orientation is more briefly discussed, and suggestions are made for some situations, while the treatment of an excrescence for which no specific data are available is also considered. The significance of the excrescence drag penalty on aircraft performance is discussed, and acceptable levels in current good design practice are suggested. ESDU

N91-15133 ESDU International Ltd., London (England).
A METHOD OF ESTIMATING A SEPARATION BOUNDARY OF TWO-DIMENSIONAL AEROFOIL SECTIONS IN TRANSONIC FLOW Abstract Only
Jun. 1990 19 p
(ESDU-81020-AMEND-A; ISSN-0141-4356) Avail: ESDU

ESDU 81020 gives a method for predicting the lift coefficient versus Mach number curve defining separation from a series of pressure distribution calculations using computer codes that strictly do not apply for flows approaching separation. From an analysis of wind-tunnel data two separation criteria were developed for use with the calculated pressure distributions, depending on whether separation occurred initially at the upper-surface upstream shock location or just upstream of the trailing edge. Separation was defined as occurring when the trailing-edge pressure coefficient diverged by 0.05 from an extrapolation of its trend with freestream Mach number or lift coefficient in attached flow. Because conditions for initial separation change along the complete separation boundary both criteria have to be considered. A detailed step-by-step explanation of the method is provided. The method was developed using calculations by the viscous Garabedian and Korn program with a lag entrainment boundary layer theory, but will apply using any comparable method for computing aerofoil pressure distributions. It applies to round-nosed aerofoils with or without camber with sharp or blunt bases. The experimental data used to develop the separation criteria covered a freestream Mach number range from 0.6 to 0.85 for Reynolds number based on chord of 2.5 to 20 million with transition fixed within a few percent

of the leading edge on both upper and lower surfaces. The method predicts the boundary within 0.03 in lift coefficient where separation lift coefficient varies slowly with Mach number and within 0.005 in Mach number were the separation Mach number varies slowly with lift coefficient. ESDU

N91-15135# Technische Hochschule, Aachen (Germany, F.R.). Fakultaet fuer Maschinenwesen.
PSEUDO REYNOLDS NUMBER EFFECTS IN TRANSONIC WIND TUNNELS Ph.D. Thesis [PSEUDO-REYNOLDSZAHLEFFEKTE IN TRANSSONISCHEN WINDKANAELEN]
FELIX AULEHLA 1989 63 p In GERMAN
(ETN-91-98493) Avail: NTIS HC/MF A04

Three types of measures are discussed, for which Mach numbers errors are of great importance: the pressure resistance of forebodies and afterbodies, the transonic maximum lift, the transonic shock location. The positive or negative pseudo Reynolds number effects vary whether the reference pressure to regulate the blower stream Mach number is inside or outside the measured length of the wind tunnel. The wall pressure average value in the blank measured length is an excellent way to determine the slightest errors in the blower stream Mach number and in axial pressure gradients during a Reynolds number variation. It is proposed, as a first step, to determine at least the average wall pressures for all total pressures of the tunnel, for all transonic wind tunnels of variable thicknesses whose Reynolds number is not exactly known. ESA

N91-15136# Technische Hochschule, Darmstadt (Germany, F.R.). Fachbereich Mechanik.
THE LAMINAR FREE JET PROBLEM, USING NEWTONIAN MEDIA Ph.D. Thesis [DAS LAMINARE FREISTRAHLPROBLEM BEI NEWTONSCHEN MEDIEN]
HARRY KNOEDLER 1989 112 p In GERMAN
(ETN-91-98494) Avail: NTIS HC/MF A06

A calculation process and results were presented for a stationary and nonstationary free jet problem for Reynolds numbers up to 100. On the basis of a global impulse evaluation, the jet swell phenomena was explained. For the critical field of the transition between channel and free surface, an asymptotical solution was given in corner field, from the point of view of nonlinear and nonstationary effects. Using the kinematic iteration process, the location of the free border could be determined. A process known up to now in the field of the finite element method (conjugate gradient least square) was decisive in the treatment of the nonlinear border value functions, using the Border Element Method (BEM). A comparison with the finite element method showed the advantage of the BEM for Reynolds number less than 100. ESA

N91-15138*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SELECTABLE TOWLINE SPIN CHUTE SYSTEM Patent Application
DANIEL M. VAIRO, inventor (to NASA) (Lockheed Engineering and Sciences Co., Hampton, VA.) and RAYMOND D. WHIPPLE, inventor (to NASA) 25 Oct. 1990 22 p
(NASA-CASE-LAR-14322-1; NAS 1.71:LAR-14322-1; US-PATENT-APPL-SN-603335) Avail: NTIS HC/MF A03 CSCL 01A

An emergency spin recovery parachute is housed within a centrally mounted housing on the aft end of an aircraft and is connected to a ring fitting within the housing. Two selectively latching shackles, connected to separate towlines are openly disposed adjacent the ring fitting. The towlines extend in opposite directions from the housing along the aircraft wing to attachment points adjacent the wing-tips, where the other end of each towline is secured. Upon pilot command, one of the open shackles latches to the ring fitting to attach the towline connected thereto, and a second command signal deploys the parachute. Suitable break-away straps secure the towlines to the aircraft surface until the parachute is deployed and the resulting force on the towline attached to the parachute overcomes the straps and permits the towline to extend to the point of attachment to exert sufficient drag on the spinning aircraft to permit the pilot to regain control of the aircraft. To employ the parachute as a drag chute to reduce landing speeds, both shackles and their respective towlines are latched to the ring fitting. NASA

N91-15981*# Tennessee Univ. Space Inst., Tullahoma.
INVESTIGATION OF TRANSONIC FLOW OVER SEGMENTED SLOTTED WIND TUNNEL WALL WITH MASS TRANSFER Final Report
M. K. BHAT, A. D. VAKILI, and J. M. WU Dec. 1990 90 p (Contract NAG2-193)
(NASA-CR-187760; NAS 1.26:187760; UTSI-90) Avail: NTIS HC/MF A05 CSCL 01/1

The flowfield on a segmented multi-slotted wind tunnel wall was studied at transonic speeds by measurements in and near the wall layer using five port cone probes. The slotted wall flowfield was observed to be three-dimensional in nature for a relatively significant distance above the slot. The boundary layer characteristics measured on the single slotted wall were found to be very sensitive to the applied suction through the slot. The perturbation in the velocity components generated due to the flow through the slot decay rapidly in the transverse direction. A vortex-like flow existed on the single slotted wall for natural ventilation but diminished with increased suction flow rate. For flow on a segmented multi-slotted wall, the normal velocity component changes were found to be maximum for measurement points located between the segmented slots atop the active chamber. The lateral influence due to applied suction and blowing, through a compartment, exceeded only slightly that in the downstream direction. Limited upstream influence was observed. Influence coefficients were determined from the data in the least-square sense for blowing and suction applied through one and two compartments. This was found to be an adequate determination of the influence coefficients for the range of mass flows considered. Author

N91-15982# National Aerospace Lab., Tokyo (Japan). ACT Study Group.
WIND TUNNEL TESTS ON FLUTTER CONTROL OF A HIGH-ASPECT-RATIO CANTILEVERED WING: CONTROL WITH LEADING-EDGE AND TRAILING-EDGE CONTROL SURFACES Report No. 2
Jun. 1990 26 p In JAPANESE; ENGLISH summary
(NAL-TR-1070; ISSN-0389-4010) Avail: NTIS HC/MF A03

Control laws were synthesized for active flutter suppression of a transport-type high aspect-ratio wing using both the leading-edge and the trailing-edge control surfaces. Wind tunnel tests were conducted in the NAL 5.5m x 6.5m low-speed wind tunnel in order to verify these control laws. The wing model has two accelerometers as sensors co-located at the control surfaces. The Linear Quadratic Gaussian (LQG) optimal control law synthesis method was applied to this multi-input, multi-output system to yield full order control laws. The order reduction procedure based on chained aggregation, together with some engineering manipulation, reduced the original 17th order controller to the decoupled second order practical controller. This synthesis method was verified to be effective by wind tunnel tests. In spite of the violent nature of clean wing flutter, the control law attained 13 percent increase in flutter speed in the test. Author

N91-15983# National Aerospace Lab., Tokyo (Japan).
AN EXPERIMENT ON SUPERSONIC TURBULENT MIXING LAYERS: SUPERSONIC-SUBSONIC TWO-STREAM LAYERS
ATSUO MURAKAMI, TOMOYUKI KOMURO, KENJI KUDOU, GORO MASUYA, and NOBUO CHINZEI May 1990 17 p In JAPANESE; ENGLISH summary
(NAL-TR-1066; ISSN-0389-4010) Avail: NTIS HC/MF A03

An experimental study was made on supersonic-subsonic two-stream mixing layers with a high-velocity side free-stream Mach number of 2.3. The free-stream Mach number on the low-velocity side was 0.19, 0.49, 0.65, or 0.80. Self-similar velocity distributions approximately agreed with those of the single-stream

incompressible mixing layers. Centers of the mixing layers moved to the low-velocity side with decreasing velocity ratio. Values of the maximum shear stress decreased with increasing compressibility effect, and simply correlated with the spreading rates irrespective of compressibility. Compressibility effect on the spreading rate appeared stronger to the visual thickness and the density thickness than to the velocity thickness. Author

N91-15984# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
LARGE-SCALE NUMERICAL AERODYNAMIC SIMULATIONS FOR COMPLETE AIRCRAFT CONFIGURATIONS
SUSUMU TAKANASHI Jul. 1990 14 p
(NAL-TR-1073-T; ISSN-0389-4010) Avail: NTIS HC/MF A03

Navier-Stokes simulations of transonic flows were carried out for complete configurations of two kinds of test models which were designed to investigate the aerodynamic characteristics of the airplanes under development using the transonic wind tunnel. An O-O grid system for the computation is constructed by the automatic procedure based on the electro-static theory. The Reynolds-averaged Navier-Stokes equations are solved on a supercomputer, FACOM VP-400, using an implicit finite volume, upwind Total Variation Diminishing (TVD) scheme. Computed pressure distributions as well as force coefficients are also compared with the experimental data. Author

N91-15985# National Aerospace Lab., Tokyo (Japan).
CALCULATIONS FOR UNSTEADY AERODYNAMIC CHARACTERISTICS ON A 3-D LIFTING BODY IN SUBSONIC FLOW USING BOUNDARY ELEMENT METHOD
MITSUNORI YANAGIZAWA, TOSHIYUKI MORITA, and SHIGEFUMI TATSUMI May 1990 72 p In JAPANESE; ENGLISH summary
(NAL-TR-1065; ISSN-0389-4010) Avail: NTIS HC/MF A04

A boundary element method of unsteady compressible potential flow around lifting bodies having arbitrary configurations and harmonic oscillation motions was developed using Green's function. Morino described the form of the integral equation relating the perturbation potential and its normal derivative. The purpose is to present a new paneling and derivative technique which can be applied to any complex configuration for evaluating the derivative of unsteady velocity potential on the surface. Numerical results for a wing-store model are presented and compared to experimental results in a subsonic flow. Good agreement was obtained between the two. Author

N91-15986*# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
HYPERSONIC SHOCK/BOUNDARY-LAYER INTERACTION DATABASE
GARY S. SETTLES and LORI J. DODSON Dec. 1990 156 p
(Contract NAG2-565)
(NASA-CR-187769; NAS 1.26:187769; PSU-ME-90/91-003)
Avail: NTIS HC/MF A08 CSCL 01/1

Turbulence modeling is generally recognized as the major problem obstructing further advances in computational fluid dynamics (CFD). A closed solution of the governing Navier-Stokes equations for turbulent flows of practical consequence is still far beyond grasp. At the same time, the simplified models of turbulence which are used to achieve closure of the Navier-Stokes equations are known to be rigorously incorrect. While these models serve a definite purpose, they are inadequate for the general prediction of hypersonic viscous/inviscid interactions, mixing problems, chemical nonequilibria, and a range of other phenomena which must be predicted in order to design a hypersonic vehicle computationally. Due to the complexity of turbulence, useful new turbulence models are synthesized only when great expertise is brought to bear and considerable intellectual energy is expended. Although this process is fundamentally theoretical, crucial guidance may be gained from carefully-executed basic experiments. Following the birth of a new model, its testing and validation once again demand comparisons with data of unimpeachable quality. This report concerns these issues which arise from the experimental aspects of hypersonic modeling and represents the results of the first phase of an effort to develop compressible turbulence models. Author

N91-15987*# MCAT Inst., San Jose, CA.
ROTORCRAFT APPLICATION OF ADVANCED COMPUTATIONAL AERODYNAMICS Final Report
SHARON STANAWAY Jan. 1991 8 p
(Contract NCC2-579)
(NASA-CR-187767; NAS 1.26:187767; MCAT-91-001) Avail: NTIS HC/MF A02 CSCL 01/1

The objective was to develop the capability to compute the unsteady viscous flow around rotor-body combinations. In the interest of tractability, the problem was divided into subprograms for: (1) computing the flow around a rotor blade in isolation; (2) computing the flow around a fuselage in isolation, and (3) integrating the pieces. Considerable progress has already been made by others toward computing the rotor in isolation (Srinivasen) and this work focused on the remaining tasks. These tasks required formulating a multi-block strategy for combining rotating blades and nonrotating components (i.e., a fuselage). Then an appropriate configuration was chosen for which suitable rotor body interference test data exists. Next, surface and volume grids were generated and state-of-the-art CFD codes were modified and applied to the problem. Author

N91-15988# Stuttgart Univ. (Germany, F.R.).
FINITE ELEMENT APPROXIMATIONS FOR TRANSONIC FLOWS Ph.D. Thesis [FINITE-ELEMENT-APPROXIMATIONEN FUER TRANSONISCHE STROEMUNGEN]
HARALD BERGER 1989 96 p In GERMAN
(ETN-91-98491) Avail: NTIS HC/MF A05

The conservative nonlinear potential equation is examined using finite element methods. This equation describes a stationary, even, friction free, adiabatic, isoenergetical and homentropic flow for an ideal gas. In the case of a subsonic flow, the nonlinear potential equation is of elliptical type. The nonlinear potential equation is derived from the continuum mechanics general equations. It is shown that the solution of an hyperbolic conservation equation should fulfill a mathematical entropoy condition. It is established that some finite element functions satisfy the discrete entropy condition. It is underlined that the convergence behavior of finite element solutions of the nonlinear potential equation in subdomains of the flow field stays strictly subsonic, e.g., the potential equation stays uniformly elliptical. The global convergence properties of finite element solutions are examined. An error analysis can be derived for these finite element solutions. ESA

N91-15989# EMA, Mansfield, TX.
EVALUATION OF ROTORWASH CHARACTERISTICS FOR TILTROTOR AND TILTWING AIRCRAFT IN HOVERING FLIGHT Final Report
SAMUEL W. FERGUSON Dec. 1990 263 p *Prepared for* Systems Control Technology, Inc., Arlington, VA
(Contract DTFA01-87-C-00014)
(SCT-90RR-18; DOT/FAA/RD-90/16) Avail: NTIS HC/MF A12

The rotorwash characteristics of eleven different types of tiltrotor and tiltwing aircraft in hovering flight are presented for comparison purposes. Rotorwash characteristics that were quantified include the mean and peak outwash velocity profiles off the left wing position (azimuth = 270 degrees) and nose position (azimuth = 0 degrees). Maximum values from each of the peak velocity and peak dynamic pressure profiles are also presented as a function of distance from the rotorcraft along both the 0 and 270 degree azimuths. Calculated personnel overturning forces are presented along both azimuths for a six foot tall person. All documented results were calculated with the ROTWASH analysis program. Flight test data, as correlated with the analysis program, are presented for the XV-15 tiltrotor and the CL-84 tiltwing. These hover characteristics do not represent the worst cast scenario characteristics which would be expected at a vertiport. Scenarios involving ambient winds and maneuvering flight near hover generate

higher rotorwash velocities. Unfortunately, the identification and prediction of worst case scenario results for comparison purposes is not presently possible. Author

N91-15992 Iowa State Univ. of Science and Technology, Ames.
COMPUTATION OF TURBULENT FLOW ABOUT UNCONVENTIONAL AIRFOIL SHAPES Ph.D. Thesis
SALAHUDDIN AHMED 1990 84 p
Avail: Univ. Microfilms Order No. DA9100414

A new nonequilibrium turbulence closure model was developed for computing wall bounded two-dimensional turbulent flows. This two-layer eddy viscosity model was motivated by the success of the Johnson-King model in separated flow regions. The influence of history effects are described by an ordinary differential equation developed from the turbulent kinetic energy equation. The performance of the present model was evaluated by solving the flow around three airfoils using the Reynolds time-averaged Navier-Stokes equations. Excellent results were obtained for both attached and separated flows about the NACA 0012 airfoil, the RAE 2822 airfoil, and the Integrated Technology A 153W airfoil. Based on the comparison of the numerical solutions with the available experimental data, it is concluded that the new nonequilibrium turbulence model accurately captures the history effects of convection and diffusion on turbulence. Dissert. Abstr.

N91-15993 Purdue Univ., West Lafayette, IN.
PROPFAN SUPERSONIC PANEL METHOD ANALYSIS AND FLUTTER PREDICTIONS Ph.D. Thesis
CHING-CHYWAN HWANG 1990 141 p
Avail: Univ. Microfilms Order No. DA9031342

A supersonic panel method analysis for propfan performance and flutter predictions was developed by extending Williams' three dimensional unsteady lifting surface theory to the supersonic speed range. The method upgrades the capability of the original (subsonic) panel code, UPROP3S, to include the propfan operating conditions at subsonic axial speeds with subsonic/supersonic tip speeds and supersonic axial speeds. The original panel code, UPROP3S, is coded for the predictions of steady performance characteristics, forced vibration, static aeroelastic deformation, and flutter. This panel code is effective and inexpensive compared to full potential, Euler, or Navier-Stokes codes. In this method the unsteady aerodynamic model is based on the three dimensional linearized compressible aerodynamic theory. A piece-wise constant load paneling technique is applied to find the blade pressure difference distributions from the lifting surface integral equation. The aeroelastic model is formulated in terms of the in-vacuum normal modes of the blades. The flutter event is determined by solving the eigenvalue problem associated with the equations of motion. The surveyed propfan wind tunnel models include the SR2, SR3, SR5, and SR7 blades. The computed results correlate very well with the measured data in both performance and flutter predictions. It is thought that this study could also lead to the emergence of a supersonic cruise propeller. Dissert. Abstr.

N91-15997# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
NUMERICAL ANALYSIS OF VISCOUS HYPERSONIC FLOW PAST A GENERIC FOREBODY
K. M. WANIE and M. A. SCHMATZ 6 Jul. 1990 13 p Presented at the 17th Congress of the International Council of the Aeronautical Sciences, Stockholm, Sweden, 9-14 Sep. 1990
(MBB/FE122/S/PUB/0407; ICAS-90-6.7.2; ETN-91-98544)
Copyright Avail: NTIS HC/MF A03

The viscous hypersonic flow past an analytically defined generic-transport aircraft forebody is numerically simulated using a Navier-Stokes code. The governing equations were written in general three dimensional curvilinear form. The sensitivity of the solutions to variations of physical parameters was investigated. Turbulence is shown to have a significant influence on boundary layer velocity profiles and boundary layer thickness but at Mach number, real gas effects and radiation play a minor role for these features while they considerably reduce the thermal loads. ESA

N91-16268# Kyushu Univ., Fukuoka (Japan). Dept. of Aeronautical Engineering.
NUMERICAL SIMULATION OF SEPARATED FLOWS AROUND A WING SECTION AT STEADY AND UNSTEADY MOTION BY A DISCRETE VORTEX METHOD
SHIGERU ASO, ATSUSHI FUJIMOTO, NAOKI FUTATSUDERA, and MASANORI HAYASHI (Nishinippon Inst. of Tech., Fukuoka, Japan) *In* Tokyo Univ., The Proceedings of the Symposium on Mechanics for Space Flight 1989 p 15-24 Mar. 1990 Original language document was announced in IAA as A90-33753
Avail: NTIS HC/MF A09

Separated flows around a wing section at pitching motion are simulated numerically by a discrete vortex method combined with a panel method. The potential flows around wing sections are expressed by vortex sheets and separated shear layers are expressed by discrete vortices. In the calculation, a separation point is determined by solving boundary layer equations. The strength of shed vortex is estimated using local velocity near separation point. Separated flows around pitching airfoils are simulated. A hysteresis of lift of airfoil at dynamic stall is obtained in the calculation. These results suggest that this method is useful to simulate separated flows around a wing section at pitching motions. Author

N91-16272# Kyushu Univ., Fukuoka (Japan). Dept. of Aeronautical Engineering.
UNSTEADY VORTEX LATTICE CALCULATION OF THE FLOW AROUND A SLENDER DELTA WING
AKIRA SAKURAI and HIROSHI UCHIHORI *In* Tokyo Univ., The Proceedings of the Symposium on Mechanics for Space Flight 1989 p 53-59 Mar. 1990
Avail: NTIS HC/MF A09

The unsteady vortex lattice method was applied to the calculation of the unsteady flow field around a slender delta wing at a high angle of attack. The result shows that the essential feature of the flow such as the formation of the leading edge vortex can be described by this model, while the detail of the calculated flow field still depends on the practical aspects of the scheme such as the selection of the viscous core radius. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A91-21229
ANALYSIS AND CERTIFICATION OF THE STARSHIP ALL-COMPOSITE AIRFRAME
ANN L. KOLARIK (Beech Aircraft Corp., Wichita, KS) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 10 p. (SAE PAPER 900997) Copyright

Beech Aircraft has completed Federal Aviation Administration (FAA) certification of the all graphite/epoxy Starship I business airplane. This paper describes the analysis and test procedures developed and documented during the FAA certification program. These procedures satisfy Federal Aviation Regulations (FAR Part 23) and the special conditions pertaining to composite certification. Author

A91-21486#
AIRCRAFT ACCIDENT FLIGHT PROFILE SIMULATION AND ANIMATION
D. E. CALKINS (Washington, University, Seattle) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs (AIAA PAPER 91-0422) Copyright

During 1987, Northwest Airlines Flight 255 crashed in Detroit in the summer, and Continental Airlines Flight 1713 crashed in Denver in the winter. This paper will describe the reconstruction,

simulation and animation of the time dependent flight profile for each accident through a process known as forensic engineering. Forensic engineering is the application of scientific and engineering knowledge to legal matters, such as accident reconstruction. The flight profiles were reconstructed as an aid in visualizing the sequence of events and the factors involved in each accident.
Author

A91-21494#
COMPARISON OF RIME AND GLAZE DEFORMATION AND FAILURE PROPERTIES
A. D. REICH (BF Goodrich Aerospace, De-Icing Systems, Uniontown, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0446) Copyright

Young's Modulus, E, and the fracture strength, P(f), of glaze and rime ice were measured. The two ice forms were obtained in the 5-10 C temperature zone by using two different levels of liquid water content and drop size. A simply supported beam configuration was used for the ice samples both with and without metal substrates. A model development was performed using simple beam theory to obtain ice properties from ice+foil (substrate) beams. Samples were shaped to size and measured in a cold room located next to the icing tunnel. The glaze values for E and P(f) were found to be 410,000 psi and 199.2 psi, respectively. Rime failure was observed to occur either abruptly or continuously. Two failure modes were introduced to account for this. The rime ice properties consistent with the continuous, mode 2, failure were found to be E = 22,000 psi and P(f) = 18.3 psi. Debonding phenomena, observed during beam deformation, were used to establish qualitative adhesion strength relationships. Author

A91-21532#
CERTIFICATION OF FOKKER 50 AND FOKKER 100 FOR OPERATION IN ICING CONDITIONS
J. N. BOER and J. VAN HENGST (Fokker Aircraft, Amsterdam, Netherlands) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p.
(AIAA PAPER 91-0561) Copyright

The certification process for flight in icing conditions for the Fokker 50 and Fokker 100 is described. The various tests necessary for demonstrating compliance with this requirement, such as laboratory tests, flight tests in dry air, flight tests with simulated ice shapes and flight tests in natural icing conditions, are discussed. It is shown that the Fokker 50 and Fokker 100 are able to operate safely in icing conditions when the relevant flight manual statements are observed. Y.P.Q.

A91-21581*# Akron Univ., OH.
STATISTICAL STRUCTURAL ANALYSIS OF ROTOR IMPACT ICE SHEDDING
C. J. KELLACKY, M. L. CHU, and R. J. SCAVUZZO (Akron, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract NAG3-479)
(AIAA PAPER 91-0663)

The statistical characteristics of impact ice shear strength are analyzed, with emphasis placed on the most probable shear strength and statistical distribution of an ice deposit. Several distribution types are considered: the Weibull, two-parameter Weibull, and exponential distributions, as well as the Gumbell distribution of the smallest extreme and the Gumbell distribution of the largest extreme. It is concluded that the Weibull distribution yields the best results; however, the expected life, shape parameter, and scale parameter should be determined separately for each case of varying wind speed and droplet size. The theoretical predictions of shear stresses in a specific rotating ice shape are compared, and it is noted that when the effects of lift are added to the theoretical model and the interference is calculated with a new mean and standard deviation, the probability of ice shed is computed as 36.64 pct. V.T.

A91-21582*# Akron Univ., OH.
INFLUENCE OF AERODYNAMIC FORCES IN ICE SHEDDING
R. J. SCAVUZZO, M. L. CHU, and V. ANANTHASWAMY (Akron, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(Contract NAG3-479)
(AIAA PAPER 91-0664)

Stresses in accreted ice on a typical airfoil impact ice caused by aerodynamic forces have been studied using finite element analyses. The objective of this study is to determine the significance of these stresses relative to values needed to cause ice shedding. In the case studied, stresses are not significant (less than 10 percent) when compared to the fracture value for airspeeds below a Mach number of 0.45. Above this velocity, the influence of aerodynamic forces on impact ice stresses should be considered in analyses of ice shedding. Author

A91-21583*# Toledo Univ., OH.
NUMERICAL SIMULATION OF ICING, DEICING, AND SHEDDING
W. B. WRIGHT, K. J. DEWITT, and T. G. KEITH, JR. (Toledo, University, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. Research supported by Boeing Helicopters, Ohio Aerospace Institute, and NASA. refs
(AIAA PAPER 91-0665)

An algorithm has been developed to numerically model the concurrent phenomena of two-dimensional transient heat transfer, ice accretion, ice shedding and ice trajectory which arise from the use of electrothermal pad. The Alternating Direction Implicit method is used to simultaneously solve the heat transfer and accretion equations occurring in the multilayered body covered with ice. In order to model the phase change between ice and water, a technique was used which assumes a phase for each node. This allows the equations to be linearized such that a direct solution is possible. This technique requires an iterative procedure to find the correct phase at each node. The computer program developed to find this solution has been integrated with the NASA-Lewis flow/trajectory code LEWICE. Author

A91-21584#
ANALYSIS OF INFRARED THERMOGRAPHY DATA FOR ICING APPLICATIONS
LINDA SMITH BOYD (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0666) Copyright

This paper discusses the use of infrared thermography data to verify theoretical temperature distributions induced by aerodynamic frictional heating and generated by electrothermal heaters used for ice protection on propeller blades. The thermal imaging data proved to be useful for analyzing and understanding steady-state and transient temperature distributions on nonrotating propeller blade heaters and for analyzing steady-state temperature distributions on rotating prop-fan blades. The infrared thermal imaging techniques are found to offer a significant potential for cost effectively obtaining surface temperature characteristics on aircraft surfaces that require ice protection systems. Author

A91-21585#
DEVELOPMENT OF A WORKSTATION-BASED FLIGHT DATA ANALYSIS PACKAGE
KENNETH B. CENTER and F. CARROLL DOUGHERTY (Colorado, University, Boulder) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p.
(AIAA PAPER 91-0668) Copyright

The paper presents a flight-data analysis package providing the real-time animation of airline incidents, based on a flight simulator program and an IRIS workstation with the ability to perform rapid geometry operations such as coordinate transforms and polygon drawings. Both four- and sixteen-channel flight-recorder data sets can be used as input. Sequence speed and viewpoint are controlled by the user interactively, and a full set of important flight parameters is displayed so that a

comprehensive overview of the aircraft's status may be analyzed at any point in time. The modeling of possible complications in the aircraft flight path such as weather features, ground structures, or other aircraft is possible. Data from three recent crashes are analyzed, along with two hypothetical scenarios. V.T.

A91-22500*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A REVIEW OF ICE ACCRETION DATA FROM A MODEL ROTOR ICING TEST AND COMPARISON WITH THEORY
RANDALL K. BRITTON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) and THOMAS H. BOND (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 34 p. Previously announced in STAR as N91-13421. refs
(AIAA PAPER 91-0661) Copyright

An experiment was conducted by the Helicopter Icing Consortium (HIC) in the NASA Lewis Icing Research Tunnel (IRT) in which a 1/6 scale fuselage model of a UH-60A Black Hawk helicopter with a generic rotor was subjected to a wide range of icing conditions. The HIC consists of members from NASA, Bell Helicopter, Boeing Helicopter, McDonnell Douglas Helicopters, Sikorsky Aircraft, and Texas A&M University. Data was taken in the form of rotor torque, internal force balance measurements, blade strain gage loading, and two dimensional ice shape tracings. A review of the ice shape data is performed with special attention given to repeatability and correctness of trends in terms of radial variation, rotational speed, icing time, temperature, liquid water content, and volumetric median droplet size. Moreover, an indepth comparison between the experimental data and the analysis of NASA's ice accretion code LEWICE is given. Finally, conclusions are shown as to the quality of the ice accretion data and the predictability of the data base as a whole. Recommendations are also given for improving data taking technique as well as potential future work. Author

A91-24120
THE VERTICAL FLIGHT COMMUTER - A SOLUTION TO URBAN TRANSPORTATION PROBLEMS
MORRIS E. FLATER (HubExpress Airlines, Stow, MA) Vertiflite (ISSN 0042-4455), vol. 37, Jan.-Feb. 1991, p. 29-31.
Copyright

The tiltrotor craft is described as a high-leverage technology which addresses the public transportation problems of the next three decades. Statistics are presented which illustrate the increasing congestion in the environs of U.S. airports. The subsequent need for an efficient transportation link with major airports in order to supply air carrier markets in suburbs with the passenger feeds they require is emphasized. A commuter service in Boston is used as a successful example of a tiltrotor craft service which provides 10-15 minutes commuting time to Logan Airport from the rooftops of Boston's buildings at costs ranging from 59 to 79 dollars. It is noted that disadvantages of the tiltrotor craft include a higher operations and maintenance cost than for most fixed-wing craft, while advantages cited include the high demand for this type of service, excellent service at relatively low cost, and the lack of competition from fixed-wing craft for this type of service. L.K.S.

A91-24121
OVERCOMING OBSTACLES TO VERTICAL FLIGHT PUBLIC TRANSPORT OPERATIONS
JOHN W. LEVERTON (E. H. Industries, Inc., Arlington, VA) Vertiflite (ISSN 0042-4455), vol. 37, Jan.-Feb. 1991, p. 34-38.
Copyright

Two issues of technical importance concerning the viability of advanced rotorcraft and civil tilt-rotor (CTR) aircraft as a viable segment of the air transportation industry are discussed. These include the use of 'steep approaches', that is, steeper than the 3 deg used by fixed wing aircraft, and the required operational performance standards. The debate surrounding FAA acceptance of angles greater than 3 deg, including airspace and environmental issues, is outlined. It is concluded that, in the future, true vertical approach should be considered for advanced rotorcraft and CTR. It is recommended that in the meantime an initial step to 6-7.5 deg should be considered for advanced rotorcraft/CTR. Public transportation requirements are discussed. Specifically, the ICAO Annex 6, dealing with helicopter performance, and Annex 14, dealing with heliports, are examined and the 'zero field length' Cat A take-off is discussed. The advanced technology rotorcraft EH10 is also examined in detail. L.K.S.

A91-24122* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE CIVIL TILTROTOR AIRCRAFT'S POTENTIAL IN DEVELOPING ECONOMIES
LARRY R. ALTON (NASA, Ames Research Center, Moffett Field, CA) and THEODORE LANE Vertiflite (ISSN 0042-4455), vol. 37, Jan.-Feb. 1991, p. 46-51. refs
Copyright

The civilian tiltrotor (CTR) is analyzed as a new transportation technology with the potential for changing one of the key economic factors linked to Third World economic development. It is contended that efficient, low-cost transport services are a necessary condition for the economic development of Third World countries and that the CTR's capabilities and operating costs can provide more efficient transport services than have heretofore been available to such countries. A case study of potential CTR use among the nations of the Carribean Basin region appears to offer both analytical and empirical support to these contentions. The analysis indicates that normal market mechanisms are adequate for development of air cargo services using the CTR's capabilities. It is suggested that implementation of this service may require new institutional arrangements, but overall it is concluded that tiltrotor technology could make an important contribution to the economic development of Third World countries. L.K.S.

A91-24123
TO CAPTURE THE MARKET PUT THE REAL 'V' IN VTOL
JOHN F. WARD (Ward Associates, Watertown, NY) Vertiflite (ISSN 0042-4455), vol. 37, Jan.-Feb. 1991, p. 58-61.
Copyright

A view of the civil rotorcraft transportation system design challenge is offered. The focus is on an augmented, all-weather, VTOL operating capability requirement. The challenge discussed is to develop a safe, reliable, nonintrusive VTOL precision terminal area operating system for use in the urban and congested airport environment. It is suggested that this challenging design requirement can be fully met in a second-generation commercial rotorcraft transportation system. Although this application of technology will not be viable for some time, the near-term system would utilize the current microwave landing system to achieve steep (perhaps up to 15 degrees), although not vertical, approach and departure angles. Aircraft design integration and augmentation and ground-based and vertiport guidance system design augmentation are discussed. L.K.S.

N91-15140# National Transportation Safety Board, Washington, DC.
AIRCRAFT INCIDENT REPORT: USAIR FLIGHT 105, BOEING 737-200, N283AU, KANSAS CITY INTERNATIONAL AIRPORT, MISSOURI, SEPTEMBER 8, 1989
11 Sep. 1990 196 p
(PB90-910404; NTSB/AAR-90/04) Avail: NTIS HC/MF A09
CSCL 01C

The premature descent below minimum descent altitude of USAir flight 105 on approach to Kansas City International Airport, Missouri, on September 8, 1989 is explained. The aircraft struck and severed four electronic transmission cables, located about 75 feet above the ground, approximately 7,000 feet east of the runway threshold. The safety issues discussed in the report are identification of potentially confusing features near runways on instrument approach charts; FAA oversight of air traffic control quality assurance; FAA training of and guidance to operations inspectors; application of visual descent points to training in and execution of nonprecision instrument approaches, and incorporation

of requirements for visual descent points in Federal Aviation Regulation (FAR) Part 135 operations; communications of weather information between air traffic control and the National Weather Service; and revision of minimum safe altitude warning inhibit areas. Safety recommendations addressing these issues were made to the FAA and the National Weather Service. Author

N91-15141*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, VA.
REPORT OF THE WORKSHOP ON AVIATION SAFETY/AUTOMATION PROGRAM
SAMUEL A. MORELLO, ed. Oct. 1990 45 p Workshop held *in Virginia Beach, VA, 10 Oct. 1989*
(NASA-CP-10054; NAS 1.55:10054) Avail: NTIS HC/MF A03 CSCL 01C

As part of NASA's responsibility to encourage and facilitate active exchange of information and ideas among members of the aviation community, an Aviation Safety/Automation workshop was organized and sponsored by the Flight Management Division of NASA Langley Research Center. The one-day workshop was held on October 10, 1989, at the Sheraton Beach Inn and Conference Center in Virginia Beach, Virginia. Participants were invited from industry, government, and universities to discuss critical questions and issues concerning the rapid introduction and utilization of advanced computer-based technology into the flight deck and air traffic controller workstation environments. The workshop was attended by *approximately 30 discipline experts, automation and* human factors researchers, and research and development managers. The goal of the workshop was to address major issues identified by the NASA Aviation Safety/Automation Program. Here, the results of the workshop are documented. The ideas, thoughts, and concepts were developed by the workshop participants. The findings, however, have been synthesized into a final report primarily by the NASA researchers. Author

N91-15143# National Transportation Safety Board, Washington, DC. Office of Aviation Safety.
AIRCRAFT ACCIDENT REPORT: UNITED AIRLINES FLIGHT 232, MCDONNELL DOUGLAS DC-10-10, SIOUX GATEWAY AIRPORT, SIOUX CITY, IOWA, 19 JULY 1989
1 Nov. 1990 127 p
(PB90-910406; NTSB/AAR-90/06) Avail: NTIS HC/MF A07 CSCL 01C

The crash of a United Airlines McDonnell Douglas DC-10-10 in Sioux City, Iowa, on July 19, 1989 is explained. The safety issues discussed in the report are engine fan rotor assembly design, certification, manufacturing, and inspection; maintenance and inspection of engine fan rotor assemblies; hydraulic flight control system design, certification, and protection from uncontained engine debris; cabin safety, including infant restraint systems; and aircraft rescue and *firefighting facilities. Safety recommendations* addressing these issues were made to the Federal Aviation Administration and the U.S. Air Force. Author

N91-15999# Civil Aeromedical Inst., Oklahoma City, OK.
DEVELOPMENT OF A CRASHWORTHY SEAT FOR COMMUTER AIRCRAFT Final Report
VAN GOWDY Sep. 1990 13 p Sponsored by FAA, Washington, DC
(AD-A227486; DOT/FAA/AM-90/11) Avail: NTIS HC/MF A03 CSCL 01/3

A series of dynamic impact tests were conducted using a prototype seat with an energy absorbing mechanism as part of the seat pan. The seat frame was designed to represent a typical commuter aircraft passenger seat. Tests were conducted in an orientation simulating a vertical impact with a 30 deg nose-down aircraft attitude. The impact severity for these tests ranged from 15 to 33 Gs. Seat pan stroke and occupant lumbar reaction forces were measured. Results indicate the axial force measured in the lumbar spine of a fiftieth percentile Hybrid II dummy can be limited to a peak value less than 1500 pounds during vertical impact tests of 33 G with a seat pan stroke distance of 6.3 inches. GRA

N91-16000# Planungsbuero Luftraumnutzer, Frankfurt (Germany, F.R.).
THE EUROPEAN FLIGHT SAFETY CRISIS: COSTS AND SOLUTION [DIE KRISE DER EUROPAEISCHEN FLUGSICHERUNG: DIE KOSTEN UND IHRE LOESUNG]
Sep. 1989 69 p In GERMAN
(ETN-91-98490) Avail: NTIS HC/MF A04

The European airspace structure is based on political and not commercial considerations. The costs of the European flight safety crisis, in particular the costs of the delays, were rated at ten billion German marks. A drastic cost increase is still expected up to year 2000, as the air traffic is expected to double. It is necessary *to harmonize the 22 different national safety systems. The long* term solution is a unique, fully integrated flight safety system. A two phase planning is proposed, including the creation of a European flight safety organization. ESA

N91-16001*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
POTENTIAL USE OF TILTROTOR AIRCRAFT IN CANADIAN AVIATION
DENYSE GAZDAG (Versatec, Inc., Santa Clara, CA.) and LARRY ALTON Dec. 1990 37 p
(NASA-TM-102245; A-89269; NAS 1.15:102245) Avail: NTIS HC/MF A03 CSCL 01/3

The aviation system in Canada is described as it relates to the potential applicability of tiltrotor technology. Commuter service in two corridors, the Vancouver-Victoria route on the west coast and the heavily traveled Montreal-Toronto corridor in eastern Canada, are examined. The operation of air service from the near-downtown Toronto STOLport and from the Vancouver-Victoria downtown heliport facilities is described. The emergency medical services, search and rescue, and natural resources development sectors are described with regard to the needs that tiltrotor technology could uniquely meet in these areas. The airport construction program in isolated communities of northern Quebec and possible tiltrotor service in northern regions are reviewed. The Federal and provincial governments' financial support policy regarding the aeronautical industry is to encourage the establishment and expansion of businesses in the field of aeronautics and to make possible the acquisition of new technology. This policy has implications for the tiltrotor program. Author

N91-16002 Bundesanstalt fuer Flugsicherung, Frankfurt am Main (Germany, F.R.).
ACTIVITIES REPORT OF THE GERMAN FEDERAL INSTITUTE FOR FLIGHT SAFETY Annual Report, 1989 [BUNDESANSTALT FUER FLUGSICHERUNG, JAHRESBERICHT 1989]
Jul. 1990 51 p In GERMAN
(ETN-91-98644) Copyright Avail: Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Fed. Republic of Germany

The air traffic flow, as well as the air traffic flow control and measures envisaged to increase the air traffic safety are presented. The problems raised by airplane noises, flight incidents and accidents are mentioned. The progress achieved in fields, such as Doppler omnidirectional radio range, instrument and microwave landing systems, radar renewable and modernization airspace utilization, training simulation, weather data information system, and electronic data processing, are outlined. Subjects covered in testing were: computer oriented metering planning and advisory system, experimental working position simulation, radar data quality control and radar analysis support systems. The cooperation with international airflight organizations and the participation in international conferences are mentioned. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A91-20900
NORTH ATLANTIC AIR TRAFFIC CONTROL
PETER BERRY Aeronautical Journal (ISSN 0001-9240), vol. 94, Nov. 1990, p. 318-323.
Copyright
The more recent improvements to North Atlantic air traffic control are discussed. The early introduction of computers providing on-line data interchange between Oceanic Control Centers and the current computer supported services provided by the Shanwick (Prestwick and Shannon) and Gander Area Control Centers are reviewed. Separation standards, supersonic routes, and safety standards are examined. Flight level assignment and North Atlantic track signal are investigated and flight departures, oceanic clearance, in-flight communications, and transfer of control are all discussed. L.K.S.

A91-20979
A REAL TIME EXPERT-AIDED TRAJECTORY ESTIMATOR USING MULTIPLE TSPI SOURCES INCLUDING A UNIQUE ON-AIRCRAFT POSITIONING SYSTEM
M. DECOLATOR, L. SLEDJESKI, and L. STONE (Grumman Corp., Calverton, NY) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 1A.4-1 to 1A.4-7. refs
Copyright
A system was constructed that extends restricted test instrumented airspace, permits tracking more aircraft from the test facility than the number of radars available, maintains tracking accuracy at long ranges, and allows autonomous low altitude overland testing. The interdependent elements of the system, i.e., Radarbet, Mini-Map, Geo, and the Expert System, are described. Radarbet provides accurate trajectory data representing aircraft velocities and spatial positions for up to eight aircraft simultaneously, while Geo provides absolute and relative positioning information between the Radarbet tracks. A pre-mission setup file that is interpreted in real-time permits Radarbet to correctly access and merge multiple streams of time, space, and position information (TSPI) data coming from ground-based radar, IFF tracking systems, and airborne-based aircraft/missile telemetry streams. Geo, Radarbet, and Mini-Map, in conjunction with the Expert System have been in operation at Grumman's flight test facility and have proven themselves in the F-14D demonstration and other test programs. R.E.P.

A91-20985
HIGH PRECISION REAL TIME AIRPLANE POSITIONING SYSTEM WITH FULL NAVIGATIONAL CAPABILITIES FOR FLIGHT TESTING
TH. JACOB and G. SCHAENZER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2A.5-1 to 2A.5-9. refs
Copyright
A system concept is presented that results in high precise position, attitude and flight path information for a moving platform, such as an aircraft. This information is measured by an integrated system based on the GPS and provides real-time capability (23 samples/sec) using a micro vax in connection with an array processor. Various concepts of system integration are defined and the results of a closed-loop mechanization of a Kalman filter coupling GPS and INS implemented in this integrated flight path measurement have been checked by simulation and flight test. R.E.P.

A91-20998
GPS - THE LOGICAL CHOICE FOR FLIGHT TEST TRACKING OF AIRCRAFT
CARL E. HOEFENER and ROBERT VAN WECHEL (Interstate Electronics Corp., Anaheim, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 4.6-1 to 4.6-3.
Copyright
Precise time and space-position information (TSPI) is necessary during aircraft flight testing for such reasons as flight safety, flight test control, navigation system evaluation, flight performance, and determination of balanced field length. Although GPS is designed as a precision radio navigation system, it is now being applied as a TSPI source on flight test ranges. GPS has many advantages over alternative TSPI techniques: the determination of a more accurate position, no range presurvey requirements, provision of precise time for all users, facilitating interrange operations through a worldwide common-grid system, providing over-the-horizon extension of existing ranges, accommodating an unlimited number of operators, providing position solution to ground level, and providing portable tracking capability. R.E.P.

A91-21203
ACARS
R. E. CLAYTON (British Airways, PLC, Heathrow, England) IN: Maintenance of modern avionics systems; Proceedings of the Conference, Heathrow, England, May 9, 1989. London, Royal Aeronautical Society, 1989, p. 2.0-2.12.
Copyright
ACARS is a VHF digital data link that connects an operational aircraft with its ground communications network. This system complements the existing air/ground voice communications and provides a communication capability between the advanced avionics of present and future aircraft and the ground airline data processing facilities. Potential problem information will be reported to the ground using fault reporting/fault isolation manual code or electronically on the new generation of aircraft employing the central maintenance system. Details are provided for the ACARS/AIRCOM system and its operation using both the ground network and airborne systems. ACARS and the new generation of aircraft avionic systems will give maintenance technicians the visibility of engine performance data in real time plus advance warning of aircraft performance events that may require maintenance action. R.E.P.

A91-22203#
PLANNING SUPPORT SYSTEM FOR AIR TRAFFIC CONTROL [SYSTEME ZUR PLANUNGSUNTERSTUETZUNG BEI DER FLUGVERKEHRSKONTROLLE]
U. VOELCKERS (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 3, 1990, p. 373-380. In German.
The role of planning in air traffic management is outlined, and the basic criteria and solution principles for designing planning systems for ATC are discussed. An overview is given of the COMPAS system, which supports pilots in approach flight to airports. The role of automation in COMPAS is described. C.D.

A91-22815
EVALUATION OF HAND HELD LASER COMMUNICATORS FOR AIRBORNE APPLICATIONS
ROBERT J. FELDMANN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: Free-space laser communication technologies II; Proceedings of the Meeting, Los Angeles, CA, Jan. 15-17, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 431-438.
Copyright
The viability of replacing flashlight signals by a hand-held laser communicator for low-probability-of-intercept voice communications

is demonstrated. Potential sources for detecting the laser communication signals are examined and evaluated, and system improvements with regard to the concept of deployment are discussed. The specifications of a laser communicator are presented. I.S.

A91-22904
MODULATION AND CODING FOR THE AERONAUTICAL SATELLITE CHANNEL
ANDREAS NEUL (DLR, Institut fuer Nachrichtentechnik, Oberpfaffenhofen, Federal Republic of Germany) (Informationstechnische Gesellschaft, European Conference on Satellite Communications, 1st (ECSC-1), Munich, Federal Republic of Germany, Nov. 28-30, 1989) Space Communications (ISSN 0924-8625), vol. 7, Nov. 1990, p. 311-318. refs
Copyright

Digital satellite links are to replace unreliable HF connections currently used for communication with aircraft. This paper presents a generalized Rician fading model of the aeronautical satellite channel based on data acquired during a number of measurement flights. The derived model is then used to evaluate the performance of DPSK modulation and convolutional coding for its application in the aeronautical channel. Author

A91-23145
MODERN AIRBORNE EARLY WARNING RADARS
STEPHEN L. JOHNSTON (International Radar Directory, Huntsville, AL) and WILLIAM C. MORCHIN Microwave Journal (ISSN 0192-6225), vol. 34, Jan. 1991, p. 30, 33, 35 (9 ff.). refs
Copyright

A survey of airborne early warning (AEW) radars is presented, starting with descriptions of AEW systems. Radars for battlefield surveillance and sea search are discussed as illustrative examples. Tables giving the basic characteristics of 40 AEW radars are presented. Y.P.Q.

A91-23548
FUTURE AERONAUTIC ENVIRONMENT - FMS/ATC/PILOT
R. DEQUE and P. BACHELIER (Aerospatiale, Toulouse, France) (European Aerospace Conference on Civil Aviation Operations - Problems, Solutions and Actions, 3rd, London, England, May 22-24, 1990) Aeronautical Journal (ISSN 0001-9240), vol. 94, Dec. 1990, p. 341-343.
Copyright

A review is presented of the evolution of air-ground data links developed over the last decade to meet the airlines' operational requirements whose scope will be extended in future years. Ground-air digital communications have developed over the last decade to fill initially the airlines operating requirements, utilizing a VHF link. Some details are discussed in the areas of flight management systems and the interface with ATC and the flight crew, system automation, and optimized monitoring by the use of CRT displays. Whichever optimization principles are used the processing performed by the ground systems will require the on-board flight management systems to perform specific calculations. R.E.P.

N91-16003# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
OPTIMAL KALMAN FILTER INTEGRATION OF A GLOBAL POSITIONING SYSTEM RECEIVER AND AN LN-94 INERTIAL NAVIGATION SYSTEM M.S. Thesis
JAMES LAWRENCE HIRNING Sep. 1990 121 p
(AD-A227222; AFIT/GE/ENG/90S-02) Avail: NTIS HC/MF A06 CSCL 17/7

This research develops and attempts to implement a Kalman filter integration of a Phase 3 Global Positioning System (GPS) five channel receiver and an LN-94 Inertial Navigation System (INS). The GPS provides highly accurate position and velocity information in low dynamic environments. An INS provides position and velocity information with lower accuracy over long periods of time, but it is highly responsive in dynamic maneuvers or at high frequencies. The INS has the added advantage of requiring no signals external to the vehicle to function. The integration of these two systems provide more precise information under a wider variety of situations. A truth model for the INS is verified. A GPS error model is developed and combined with the INS model to provide GPS-aided INS navigation. This model is used to predict baseline performance of all full ordered filter. Attempts are made to utilize the filter with empirical data. The data is analyzed, and suggestions are made about ways to account for the errors in evidence. Results to date are presented and analyzed. GRA

N91-16004# Mitre Corp., Bedford, MA.
A SUCCESSIVE PARTIAL-RELAXATION GAUSSIAN ALGORITHM FOR AREA NAVIGATION OPERATIONS WITH THE MICROWAVE LANDING SYSTEM (MLS) Final Report
PATRICIA M. HATZIS and FREDERIC D. POWELL Oct. 1990 45 p
(Contract F19628-89-C-0001; AF PROJ. 5420)
(AD-A228871; MTR-10910; ESD-TR-90-326) Avail: NTIS HC/MF A03 CSCL 17/7

Position reconstruction algorithms (PRAs) based on Gaussian techniques converge very slowly, or diverge, for some geometries of ground unit and aircraft location which are within MLS system coverage. On the other hand, algorithms based on Newton-Raphson techniques usually converge very rapidly but impose a significantly greater storage requirement and computational burden on the avionics. This report presents a modified Gaussian algorithm which uses a relaxation factor to achieve rapid convergence for all geometries, and with a computational burden much less than the equivalent Newton-Raphson algorithm. It presents the theoretical foundations of this algorithm and various results showing its effects. It also compares the algorithm's storage and computational burdens against Gaussian, rotated-coordinate Gaussian, and Newton-Raphson equivalent PRAs in the MLS context. GRA

N91-16005# Rijksluchtvaartdienst, Schiphol (Netherlands). Meetkundige Dienst.
ACTIVITIES REPORT OF THE DUTCH CIVIL AERONAUTICS BOARD Annual Report, 1989 [RIJKSLUCHTVAARTDIENST: JAARVERSLAG 1991]
ANNE MARIE STEENDIJK 1990 69 p In DUTCH and ENGLISH
(ETN-91-98472) Avail: NTIS HC/MF A04

The activities in the fields of air traffic control air transportation and infrastructure, civil areronautics school, civil aeronautics museum aviodome, national aeronautics and astronautics laboratory, responsibility in the air, aerospace safety above the North Sea, and air traffic and environment are presented. ESA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-20746#
FUNDAMENTAL CONCEPTS OF VECTORED PROPULSION
BENJAMIN GAL-OR (Technion - Israel Institute of Technology, Haifa) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 747-757. Research supported by USAF, General Electric Co., General Dynamic Corp., et al. refs
Copyright

The defining principles of partial and complete thrust-vectoring (TV) powerplants for advanced military aircraft are presented with a view to their poststall-regime maneuvering and STOL capabilities. These principles are illustratively applied to the integrated roll/yaw/pitch TV system of a family of RPVs; prototypes based on these designs have been constructed and flight tested since May, 1987, demonstrating both STOL and enhanced

maneuverability/controllability. This laboratory/RPV flight test campaign has proven both cost-effective and time-saving. A follow-up program predicated on the same methodology has been launched to upgrade such existing fighters as the F-15, F-16, and F-18 to partial-TV capabilities. O.C.

A91-20783
DESIGN FOR STRENGTH AND RIGIDITY OF A THERMOPLASTIC COMPOSITE SPEED BRAKE
C. L. ONG and H. CHIN (Aero Industrial Development Center, Aeronautical Research Laboratory, Taichung, Republic of China) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 14, Sept. 1990, p. 1-12. refs
Copyright

The unusual formability of thermoplastic composites in addition to their strength and rigidity make them attractive in the design and manufacture of structural members in aircraft. In this work the design of an aircraft speed brake, the major portion of which is made of PEEK reinforced by graphite fibers is presented. This material is thermoformed into a laminate with the appropriate sequence that satisfies the load requirement for the skin. The complex 'Z' shaped spar is made of graphite fiber-reinforced epoxy, which is cured by the autoclave vacuum-bag technique. These components together with the ribs of the speed brake are prefitted and adhesive-bonded as a unit in the fixture. Rivets are then applied to secure the assembly. The integrity of this newly developed thermoplastic speed brake is verified by conducting a series of coupon tests in addition to a full scale static test. Results were obtained by measuring the strains at six different critical points and showed that the thermoplastic speed brake can sustain up to 200 percent of the design limit load in addition to satisfying the other performance requirements. The new design shows that thermoplastics can be used in place of metals in the design of speed brakes. Author

A91-20898
THE DEVELOPMENT AND DESIGN INTEGRATION OF A VARIABLE CAMBER WING FOR LONG/MEDIUM RANGE AIRCRAFT
E. GREFF (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) Aeronautical Journal (ISSN 0001-9240), vol. 94, Nov. 1990, p. 301-312. refs
Copyright

The variable camber (VC) wing, offering an opportunity to achieve considerable improvements in operational flexibility, buffet boundaries, and performance, is described. It is estimated that, among other advantages, the VC will contribute an average reduction of 3 to 6 percent in fuel burn. Research work produced significant drag reductions and increases of the buffet boundary and led to the current concept where the trailing edge flaps and ailerons are used to modify the wing camber in cruise according to the lift demand. It is noted that a VC system requires a change in design philosophy, and several new design constraints were found to affect the extent of the supersonic region, the acceptable pressure gradients in the recompression zone, and the required surface curvature. Theoretical and wind tunnel results are presented and the effects on the system design, loads, weight, handling qualities, propulsion integration and mission performance are discussed. L.K.S.

A91-20946
THE DEVELOPMENT AND TESTING OF ACTIVE CONTROL TECHNIQUES TO MINIMISE HELICOPTER VIBRATION
ALAN E. STAPLE (Westland Helicopters, Ltd., Yeovil, England) Environmental Engineering (ISSN 0954-5824), vol. 3, Dec. 1990, p. 16, 17.
Copyright

An active control of structural response (ACSR) system, able to maintain minimal helicopter vibration in spite of the changing airframe dynamics and flight conditions, is presented. The system includes from three to six electrohydraulic actuators (each producing a maximum force of 2000 lbf and absorbing a maximum displacement of 0.01 in) incorporated into the structure using single or dual point activation. The system is optimized for a range of 15-25 Hz and maximum control frequency of 40 Hz, and it is tested under different conditions. It is suggested that the substantial reduction of the vibrations, the enhanced comfort and reliability, and the extended helicopter life due to the application of the ACSR system lead to cost savings as well. B.P.

A91-20973
GENERAL APPROACH TO DYNAMIC ANALYSIS OF ROTORCRAFT
OM P. AGRAWAL (Southern Illinois University, Carbondale, IL) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, Jan. 1991, p. 91-107. refs
Copyright

This paper presents a general-purpose mathematical formulation for the dynamic analysis of a rotorcraft consisting of flexible or rigid components, or both, that may undergo large rotations. In this formulation, two sets of coordinates are used, namely rigid-body coordinates and elastic coordinates. The rigid-body coordinates define the location and the orientation of a body frame with respect to an inertial frame. The rigid-body rotational coordinates may be Euler angles, Euler-like angles, or Euler parameters. The elastic coordinates define the elastic deformations with respect to the body frame. Nonlinear strain-displacement relations are considered in order to be able to incorporate the effect of geometric stiffening. A systematic methodology that combines the traditional finite element and multibody approaches is developed to obtain a set of differential and algebraic equations governing the dynamics of the system. The resulting set of equations is highly nonlinear. Numerical schemes to solve this set of equations are also discussed. Author

A91-20976
SOCIETY OF FLIGHT TEST ENGINEERS, ANNUAL SYMPOSIUM, 20TH, RENO, NV, SEPT. 18-21, 1989, PROCEEDINGS
Symposium sponsored by the Society of Flight Test Engineers, Computer Sciences Corp., Lockheed Corp., McDonnell Douglas Corp., et al. Lancaster, CA, Society of Flight Test Engineers, 1989, 192 p. For individual items see A91-20977 to A91-21004.
Copyright

Topics presented include a real-time expert-aided trajectory estimator using multiple time, space, and position information sources and a unique on-aircraft positioning system, a range safety flight testing technique using an external camera tracking system, and a measurement system for production flight tests of new aircraft. Also presented are the AV-8B shipboard ski jump evaluation, the use of onboard data for takeoff performance determination, a flight test management and integration program, and a high speed motion analysis. Also addressed are downwash measurement at the horizontal tail, the equipment of a research aircraft with emphasis on meteorological experiments, the development and results of the AM-X high incidence trials, and some trends in telemetry for the flight test engineer. R.E.P.

A91-20977
TORNADO AFDS/TF FLIGHT TESTING - LESSONS LEARNED
MAURIZIO ASTOLFI (Italian Air Force Studies, Research and Test Centre, Pratica di Mare, Italy) and SIMON P. DENNIS (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 1A.1-1 to 1A.1-13.
Copyright

An overview is presented of the Tornado trinational flight test program, with particular emphasis on the autopilot, the flight director and terrain following (AFDS/TF) systems. Each of the various types of flight tests is presented, and for each of these the different responsibilities of the contractors and official test centers are described. The specific approach to testing and operational acceptance of this critical flight safety and essential mission system, which is to be operated in an all-weather, low level, ECM and high threat environment, is described. The TF system has proved

to be a powerful and effective answer for all-weather, low altitude penetration and is now used on several types of aircraft and cruise missiles. R.E.P.

A91-20980
MINIMUM CONTROL SPEED - A 'THRUSTLESS' APPROACH
ALICIO LOTHARIO LOTH, JR. (Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 1B.2-1 to 1B.2-7.
Copyright

This paper describes a new procedure to flight test the minimum control speed. The procedure uses torque instead of thrust in the calculations. Advantages of this new approach are discussed, and typical test data sets are shown and analyzed. Author

A91-20986
POSITION ERROR CALIBRATION OF A PRESSURE SURVEY AIRCRAFT USING A TRAILING CONE
EDWARD N. BROWN (NCAR, Boulder, CO) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2B.2-1 to 2B.2-8. refs
Copyright

The paper reviews the trailing cone development and testing, application procedures, and the results of position error evaluation over a wide speed and altitude range. The methodology by which the Research Aviation Facility calibrated and verified the position of a Sabreliner with the installation of a trailing cone assembly in order to establish a position error base for survey altitudes up to 12,500 meters is discussed. This methodology is used to provide position error data for the complete flight envelope of an aircraft. The uncertainty or the largest expected error in the Sabreliner static pressure measurement after correction with the trailing cone position error is + or - 0.396 mb. R.E.P.

A91-20987
RPAS - RUNWAY PERFORMANCE ANALYSIS SYSTEM
A. HASS and J. CHEN (Israel Aircraft Industries, Ltd., Flight Test Engineering Dept., Lod) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2B.3-1 to 2B.3-11.
Copyright

A runway performance analysis system (RPAS) is described which is a hardware/software combination utilized to calculate runway performance and related parameters in semireal-time. This system is based exclusively on measurements telemetered from the test aircraft to the ground station, thus avoiding the long turn-around time associated with photographic or radar tracking techniques. A trapped anemometric sources algorithm is implemented in the software for evaluation of anemometric sources ground effects. Results of 137 test runs in 17 flights performed with RPAS using a Westwind 1125 corporate jet aircraft are evaluated. It is shown that the fast turnaround time and completeness of the analysis makes it possible to reduce the total number of test runs and to rapidly generate final type inspection reports and/or aircraft flight manual compatible charts. R.E.P.

A91-20988
USE OF ONBOARD DATA FOR TAKEOFF PERFORMANCE DETERMINATION
FRANK S. BROWN (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2B.4-1 to 2B.4-5. refs
Copyright

A comparison is presented between the use of a two-station phototheodolite system and the use of onboard Inertial Navigation System (INS) data to determine takeoff distances. Distances from brake release to nosewheel liftoff, brake release to main wheel liftoff, (takeoff), and the horizontal distance from brake release to the aircraft passing through 50 feet above the ground level (AGL) were compared. The data were acquired during five takeoffs using a fighter type aircraft at the Air Force Flight Test Center (AFFTC). Relative to the current phototheodolite system, the onboard INS method offers several advantages. The advantages include: (1) it requires less scheduling of resources and less advanced notice; (2) the data turnaround is faster than the phototheodolite system; and (3) it is also less expensive. Author

A91-20989
FLIGHT TESTING ANTISKID/BRAKE SYSTEMS
JIM FITZGERALD (Lockheed Aeronautical Systems Co., Burbank, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2B.5-1 to 2B.5-9.
Copyright

A review is presented of the methods to be followed for ground and flight test antiskid/brake systems. Test engineers should become familiar with all aspects of the system, e.g., steel vs. carbon brake heat sink material, the number of braked wheels, routing and length of hydraulic lines, design kinetic energy limits, pressure or torque limiting, deceleration assistance devices, pedal force requirements, FBW vs. mechanical linkage, and provisions for adjustable or programmable antiskid gains. Types of testing, instrumentation requirements (per braked wheel, related system parameters, aircraft parameters), test planning and procedures, and test experiences are described. R.E.P.

A91-20990
TESTING THE NEW SWEDISH MULTIROLE A/C - THE JAS 39 GRIPEN
BO LUNDBERG and GOSTA NISS (Saab-Scania, AB, Linkoping, Sweden) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 3.1-1 to 3.1-8.
Copyright

A review is presented of the design, development and continuing flight testing of the Gripen fighter. The aircraft has been designed to carry a variety of external loads to permit fighter, ground attack and reconnaisance missions. The flight test program to be accomplished in five prototype aircraft covers about 2300 flights over a period of five years. The beginning of this testing is presented and includes the aircraft description, simulation and ground testing, data acquisition, and data analysis, with particular attention to onboard digital data systems and the use of online telemetry and the advantages of piggy-back testing. The flight control system commands seven primary control surfaces plus leading edge flaps and airbrakes for enhanced maneuvering. R.E.P.

A91-20993* PRC Systems Services Co., Edwards, CA.
AFTI/F-111 AIRPLANE MISSION ADAPTIVE WING OPERATIONAL FLIGHT EVALUATION TECHNIQUE USING UPLINKED PILOT COMMAND CUES
ROBERT W. KEMPEL (PRC Systems Services, Aerospace Technologies Div., Edwards, CA), PAUL W. PHILLIPS (USAF, Flight Test Center, Edwards AFB, CA), C. GORDON FULLERTON, and JOHN J. BRESINA (NASA, Flight Research Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 3.6-1 to 3.6-19. refs
Copyright

NASA and the USAF have conducted a program to investigate aircraft performance improvements utilizing a mission adaptive wing (MAW). The MAW was designed and developed for the AFTI/F-111 variable-sweep aircraft to provide a hydraulically driven, smooth, and continuous variable camber of the trailing and leading edges as a function of maneuvering requirements or of flight conditions. The remotely augmented vehicle facility (RAV) at the NASA DFRF, as utilized in the MAW investigations, is described. The RAV was a dedicated, ground based, general purpose facility capable of receiving a data stream downlinked from a test vehicle, processing this data stream in a digital computer, and transmitting processed

data back to the test vehicle. It is shown that this method of flight testing provides a technique that can evaluate highly dynamic maneuvers. R.E.P.

A91-20995
X-31...FLIGHT TEST IN THE 90'S
DAVID J. RODRIGUES (Rockwell International Corp., Palmdale, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 4.2-1 to 4.2-3.
Copyright

The two major objectives of the X-31 flight test program are technical demonstration and measurement of enhanced fighter maneuverability (EFM) performance, and demonstration of EFM enhancements of tactics. EFM comprises maneuverability through the use of thrust vectoring and integrated flight controls. Thrust vectoring in the X-31 is accomplished with three thrust vectoring paddles mounted to the aft fuselage and extended aft of the engine exhaust nozzle. The ultimate goal of this flight test program is to demonstrate the tactical effectiveness of EFM structured toward the attainment of air combat maneuvers for the X-31. R.E.P.

A91-20996
FLIGHT TEST MANAGEMENT AND INTEGRATION PROGRAM
GADY LEVI (Israel Aircraft Industries, Ltd., Lod) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 4.3-1 to 4.3-7.
Copyright

A flight-test management and integration program (TMIP), based on DBASE III software and IBM hardware, has been developed in Israel Aircraft Industries for a small remotely piloted vehicle and the Astra business jet. It is designed to create a flexible and easy-to-use tool for tasks that are not suitable for full-scale main-frame management programs, yet cannot be achieved by manual tracking forms. The main features include flight plan and flight summary automatic production; a data bank that consists of seven data bases (necessary for any test program); and a package for reporting system, cross references, and software handling. The TMIP is recommended for use in small and medium-size flight-test programs, based on its unique features and good operational experience. Author

A91-21000
DOWNWASH MEASUREMENT AT THE HORIZONTAL TAIL
YOSHIO HAYASHI, HAMAKI INOKUCHI (National Aerospace Laboratory, Kakamigahara, Japan), MASAKI SAITO, and TAKASHI TSUJIMOTO (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 6.1-1 to 6.1-9. refs
Copyright

This paper describes the results of downwash measurements at the horizontal tail of 'ASKA', which is the Japanese STOL research aircraft with an Upper Surface Blowing (USB) type powered lift device. As the downwash substantially concerns lift, it becomes very large for STOL aircraft with high lift. Large increments of downwash at the horizontal tail influences the aircraft longitudinal static stability. There is also some uncertainty about the behavior of the jet efflux sheet behind the USB flap. It is important to know the flow field around the empennage. Characteristics of the flow such as downwash angle and dynamic pressure at the horizontal tail were measured by air data sensors with pitot-static tubes and vanes. The results show that: (1) the downwash and Delta-epsilon/Delta-alpha increase for power setting and USB flap angle, and (2) this system, using the pitot tube with vanes, is convenient for downwash measurements, and a heating system is required. Author

A91-21002
RANDOM AIR TURBULENCE AS A FLUTTER TEST EXCITATION SOURCE
WILLIAM J. NORTON (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 6.4-1 to 6.4-11. refs
Copyright

The use of random air turbulence as a structural excitation source for aircraft flutter clearance flight test has gained wider use in the last decade as the increased data capacity and speed of small digital computers has permitted a near real-time analysis of such data. The attractiveness of the technique is due largely to the elimination of the complexities and cost of a dedicated onboard mechanical excitation system. However, the method has a number of serious limitations and may be unsuitable in many applications. These limitations were recently demonstrated during the testing of the F-15 S/MTD (Short Takeoff and Landing/Maneuver Technology Demonstrator). The advantages and disadvantages of this flutter test excitation approach are discussed in detail. Specific examples of application and data results are presented. Author

A91-21003
ENGINE WATER INGESTION TEST
GADY LEVI and HILLEL KAIN (Israel Aircraft Industries, Ltd., Lod) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 6.5-1 to 6.5-11.
Copyright

This paper describes the logic and practice in water ingestion test in a tight budget and compressed test time schedule. The Astra business jet water ingestion certification test was completed successfully on an active runway which was available for the test for only 8 hours, but was due to be cleared at any stage of the test within 15 minutes. The test planning logic as outlined in this paper will enable successful repetition of this test for almost any type of aircraft and location within one test day. Author

A91-21125
WINDSHIELDS AND CANOPIES - A PILOT'S BEST FRIENDS
GEORGE L. WISER (Sierracin/Sylmar Corp., Advanced Programs Group, CA) Cockpit (ISSN 0742-1508), July-Sept. 1990, p. 5-27.
Copyright

The operating conditions of modern aircraft windshields and canopies are reviewed, and special attention is paid to bird impact, icing protection, protection from gunfire, field of vision, distortions, and reflections. Airliners and military aircraft are exposed to a variety of conditions including temperatures ranging from Arctic to desert, internal pressurization, aerodynamic forces, heat from supersonic speeds, nuclear and microwave radiation, and chemical warfare agents. It is pointed out that the windshield design also has to take into consideration the necessity of high transparency, critical optical quality, minimum weight, and low cost. Since none of the materials available possesses all the properties required, the design is complicated. Existing windshields can be upgraded in order to improve their effectiveness and the safety of the crew. B.P.

A91-21241
ASSESSMENT OF A POST 2000 STOVL FIGHTER
G. C. TAMPLIN, D. L. HAMMOND, and R. E. FREDETTE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 17 p. Research supported by USAF.
(SAE PAPER 901031) Copyright

An evaluation is made of the performance requirements, design features, and technology-development imperatives of a next-generation USAF defensive counterair/battlefield interdiction STOVL fighter able to replace the F-16 in the 2000-2010 time period. Numerous configurational possibilities were considered in feature tradeoff studies focusing on the effects of three different propulsion systems: (1) vectorable nozzle with ventral bypass and separate lift turbojet; (2) vectorable nozzle with ventral bypass and fan air offtake ducting; and (3) vectorable nozzle with ventral

bypass and mixed fan/main flow offtake ducting. An integrated weapons-bay feature increased supersonic drag in all cases. O.C.

A91-21256* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SMALL-SCALE EXPERIMENTS IN STOVL GROUND EFFECTS
VICTOR R. CORSIGLIA, DOUGLAS A. WARDWELL (NASA, Ames Research Center, Moffett Field, CA), and RICHARD E. KUHN SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 17 p. refs
(SAE PAPER 901060) Copyright

A series of tests has been completed in which suckdown and fountain forces and pressures were measured on circular plates and twin-tandem-jet generic STOVL (short takeoff and vertical landing) configurations. The tests were conducted using a small-scale hover rig, for jet pressure ratios up to 6 and jet temperatures up to 700 F. The measured suckdown force on a circular plate with a central jet was greater than that found with a commonly used empirical prediction method. The present data showed better agreement with other sets of data. The tests of the generic STOVL configurations were conducted to provide force and pressure data with a parametric variation of parameters so that an empirical prediction method cold be developed. The effects of jet pressure ratio and temperature were found to be small. Lift improvement devices were shown to substantially reduce the net suckdown forces. Author

A91-21258
AIRCRAFT FUEL WEIGHT PENALTY DUE TO AIR CONDITIONING
SAE Aerospace Information Report SAE AIR 1168/8, Sept. 14, 1989, 18 p. refs
(SAE AIR 1168/8) Copyright

Techniques and numerical data are presented for calculating the take-off fuel-weight penalty (assuming that the range is kept constant) imposed on a supersonic aircraft by the installation of an air-conditioning system. The methods employed quantify the relationships between the flight performance and the weight, external and momentum drag, and changes in engine performance due to the extraction of bleed air and/or shaft power. The flight range, gross weight, fuel load, payload, speed-altitude characteristics, power, and landing characteristics of the aircraft and any limitations on the length of the takeoff field are all taken into account. Typical results are presented in extensive graphs, and a sample weight-penalty computation is outlined. T.K.

A91-21259
SAE AEROSPACE FLIGHT DECK AND HANDLING QUALITIES STANDARDS FOR TRANSPORT AIRCRAFT
Warrendale, PA, Society of Automotive Engineers, 1988, 271 p. No individual items are abstracted in this volume.
(SAE ARP 4100)

This manual includes individual documents on flight deck layout and facilities, and flight deck panels, controls and displays. Also included are documents covering flight deck lighting for commercial transport aircraft, the design objectives for the handling qualities of transport aircraft, and pertinent nomenclature and abbreviations. R.E.P.

A91-21415#
AN APPROACH TO AIR-BREATHING HIGH SPEED VEHICLE SYNTHESIS
S. N. B. MURTHY (Purdue University, West Lafayette, IN) and P. CZYSZ (McDonnell Douglas Corp., Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 29 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 91-0225) Copyright

Various complications involved in the synthesis of an air-breathing high speed propulsion system are discussed. Energy analysis and availability are discussed as they pertain to the synthesis of such technology. Methods of deriving the greatest work output from various, available systems inputs are discussed for cases when propulsion, lift, and balance of moments are sought to be generated using atmospheric air up to the highest speeds. The use of system structure coefficients to evaluate performance and scope for improvement of processes, components, and system architechture is discussed. Several illustrative examples are given. Also, the method of including considerations of weights, trajectory, and control within the framework for maximizing energy availablity usage is discussed. A number of diagrams are provided including a schematic of interactions in a high speed vehicle system, a schematic of comprehensive energy analysis, a comparison of weight factors for rocket and air-breathers, and examples of structure diagrams. L.K.S.

A91-21433#
THREE-DIMENSIONAL NUMERICAL SIMULATION OF ELECTROTHERMAL DEICING SYSTEMS
ALAN D. YASLIK, KENNETH J. DE WITT, THEO G. KEITH, JR. (Toledo, University, OH), and WALTER BORONOW (McDonnell Douglas Corp., Long Beach, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 91-0267) Copyright

This paper examines three-dimensional transient heat transfer in a multi-layered body which is ice covered. The physical application studied is the process of melting and removal of ice from aircraft components by use of electrothermal heaters. In order to model the ice phase change, a predictor-corrector technique is used which assumes a phase for each ice gridpoint. This allows the use of the Method of Douglas three-dimensional alternating direction numerical solver to iteratively converge on the correct phase of each ice node for each timestep. Less than five iterations are required for convergence. Verification of the code is discussed by comparing results with those of previous one-dimensional and two-dimensional studies. Finally, three-dimensional results are presented and the usefulness of the code as a design tool is illustrated. Author

A91-21434#
NUMERICAL SIMULATION OF AN ELECTROTHERMALLY DE-ICED AIRCRAFT SURFACE USING THE FINITE ELEMENT METHOD
THEO G. KEITH, JR., KENNETH J. DE WITT (Toledo, University, OH), and J. R. HUANG AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(AIAA PAPER 91-0268) Copyright

A finite-element method, which incorporates an assumed phase state technique, is presented for the solution of one- and two-dimensional heat conduction problems with phase change. A simulation of the electrothermal de-icing of an aircraft surface is made using this method and the results are compared with existing experimental data. Comparison of predicted temperatures within a rectangle and those within an airfoil reveals the extent and importance of modeling curvature effects. When the curvature is less than 0.25, curvature effects may be neglected and a rectangular shape may be used instead of the actual curved geometry. Author

A91-21515#
APPLICATION OF TURBULENCE MODELING TO THE DESIGN OF MILITARY AIRCRAFT
BRIAN R. SMITH (General Dynamics Corp., Fort Worth, TX) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0513) Copyright

Turbulence modeling methods currently in use in the military aircraft industry are discussed. Algebraic, two equation and Reynolds stress closure models are briefly surveyed. Approaches for modeling turbulence in the near wall region and modeling of compressibility effects in hypersonic flows are reviewed. Several applications of turbulence models to military aircraft design problems are presented. These examples demonstrate the challenges involved in the application of turbulence models to complex configurationis. With this background, recommendations

are made for future research in turbulence modeling which are needed to improve the CFD predictions in the aerospace industry. Author

A91-21529#
NUMERICAL MODELING OF AN ADVANCED PNEUMATIC IMPULSE ICE PROTECTION SYSTEM (PIIP) FOR AIRCRAFT
THEO G. KEITH, JR., KENNETH J. DE WITT (Toledo, University, OH), JAMES C. PUTT, CHARLES A. MARTIN (B. F. Goodrich Co., Aerospace Div., Uniontown, OH), SUBRAMANIAM RAMAMURTHY et al. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by B. F. Goodrich Co. refs
(AIAA PAPER 91-0555) Copyright

The development of a numerical model of an advanced pneumatic impulse ice protection system, also known as PIIP, for aircraft is described in this paper. A time-dependent, compressible flow model for internal duct flow is used to model the ice protection system. The model incorporates a high resolution shock capturing method - Essentially Non-Oscillatory (ENO) Scheme with Subcell Resolution (SR) and Characteristic Direction (CR). The model consists of a tube section which expands due to the passage of shock. The model includes a grid generation scheme to account for the size of the system. The model is analyzed for different inlet and exit boundary conditions. Preliminary results are obtained for different compressor pressures and the model is shown to give results of practical use. The paper also recommends a suitable operating pressure for the compressor. Author

A91-21609#
WIND TUNNEL TESTS OF AERODYNAMIC EFFECTS OF TYPE I AND II GROUND DE/ANTI-ICING FLUIDS ON SMALL TRANSPORT AND GENERAL AVIATION AIRCRAFT DURING TAKEOFF
N. ELLIS, E. LIM, P. TEELING, and S. ZHU (Boeing Canada, de Havilland Div., Downsview) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(AIAA PAPER 91-0763) Copyright

Fluids used to 'anti-ice' the aircraft on the ground contribute to enhanced air safety by reducing the chances of airframe icing before take-off. The premise of use is that the fluids will stay on the aerodynamic surfaces long enough to prevent the formation of any ice then flow clear of the aerodynamic surfaces before lift-off. A wing tunnel test simulating take-offs has been conducted at NASA LeRCIRT. The clearing of the fluids and the effect of the residual fluid for typical commuter and general aviation aircraft was observed. The tests were two-dimensional with two sections being tested - a flapped wing and a tailplane with elevator. Selected combinations of 19 fluids in three concentrations at four temperatures and two acceleration/rotation profiles were tested. Some tests were done with extended times to rotation using the same speeds. Both the force characteristics and the wave motion of the fluid were recorded. Significant degradation of the maximum lift and drag at climb out conditions were observed for the flapped wing model. The degradation in aerodynamic performance for many of the combinations of conditions was unacceptable relative to flight safety. Increased time to rotation resulted in a substantial improvement in the aerodynamic parameters to the extent that most fluids became acceptable. The tailplane with elevator model was affected less significantly than the flapped wing model. Author

A91-21617#
FLIGHT TESTS OF THE AERODYNAMIC EFFECTS OF TYPE I AND TYPE II GROUND DE-/ANTI-ICING FLUIDS ON THE FOKKER 50 AND FOKKER 100 AIRCRAFT
J. VAN HENGST (Fokker Aircraft, Amsterdam, Netherlands) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0785) Copyright

Based on the assumption that fluids may cause both a transitory loss of lift and an increase in drag during take-off, the aerodynamic effects of Type I and Type II ground deicing/antiicing fluids on the performance characteristics of the Fokker 100 and Fokker 50 are investigated using flight and wind tunnel tests. It is found that, if the deicing/antiicing treatment is applied before take-off, no performance corrections are needed, and the flow-off behavior of the fluids is satisfactory. After take-off, the handling and control characteristics are not affected by residual fluids or possible small loss of lift, and no performance corrections are needed if the aircraft is properly deiced/antiiced with Type II fluid. B.P.

A91-22173
TESTING SOVIET CIVIL AIRCRAFT
OLIVER SUTTON Aerospace World (ISSN 0983-1592), vol. 4, Dec. 1990, p. 39-41.
Copyright

The State Scientific Research Institute of Civil Aviation in the Soviet Union is reponsible for assessing the capabilities of new aircraft and equipment, and making its certification recommendations to the State Register department, which issues the type certificate. Flight test procedures generally follow Western practices, with end-of-flight pilot qualitative reports. These pilot qualitative reports form the basis of the final handling report on the aircraft. Raw performance data are collected by onboard computers and then the numbers are reduced to ISA standard conditions after each flight. Several of the flying testbeds are described, e.g., the An-74 STOL light utility transport, which is primarily designed for operations in the Arctic and remote regions. It is equipped with Doppler-based and Soviet Omega navigation systems, and an inertial platform. The An-74's low-pressure tires, which can also be equipped with skis, allow it to land on the ice. R.E.P.

A91-22262#
DEFINITION OF SERVICE LIFE FOR FRAME OF AN AIRPLANE
XIANGJIONG FU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B492-B494. In Chinese, with abstract in English. refs

The maximum service period reached safely and economically by frames of an airplane is defined as service life. This definition is different from the 'safe life' or 'economic life' specified in MILA-008866A or MIL-A-87221, respectively. It is explicated that the service life is related to the overall process of production from material to operation management. The paper also points out the way to obtain the service life. Author

A91-22266#
IMPROVED DESIGN OF THE ERROR-PROOF FILLER COVER OF AIRCRAFT FUEL SYSTEM
XIDING SUN (Chengdu Aircraft Factory, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B507, B508. In Chinese, with abstract in English.

A91-22302
TECHNOLOGICAL FORECAST OF VTOL WEIGHT EMPTY FRACTION IN THE YEAR 2020
JOYCE E. MACLENNAN (Sikorsky Aircraft, Stratford, CT) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 38 p. refs
(SAWE PAPER 1871) Copyright

A Delphi forecasting study has been conducted in view of an array of identified potential VTOL-related technology breakthroughs and 40 years' worth of weight empty fraction trend data, in order to estimate possible weight empty fraction levels 30 years from the present. Among the emerging technologies that could reduce VTOL weight are the 'all-glass' cockpit, the bearingless main rotor, all-composite airframes, fly-by-light controls, improved engine drives, innovative antitorque systems, and advanced technology engines. Offsetting these potential weight benefits are requirements for radar/lidar warning, nuclear hardening, better maintainability, low observability, increased agility, NBC protection, and all-weather target identification. O.C.

A91-22317
EFFECTS OF EXTERNAL LOADS ON ONBOARD WEIGHT AND BALANCE SYSTEMS
MATTHEW L. NOLAN (Boeing Commercial Airplanes, Seattle, WA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 22 p.
(SAWE PAPER 1895) Copyright

Onboard weight-and-balance systems employed on commercial aircraft to ensure adherence to the certified weight and center-of-gravity limits automate the previously manual process of mass additions. They are, however, subject to uncertainties that encompass load-sensing equipment tolerances and the effects of such external loads as wind, ice, rain, snow, and asymmetrical gear loads. An effort is presently made to characterize these external load-caused uncertainties relative to manual reckoning efforts; center-of-gravity restrictions are developed to account for the external loads on illustrative large (B747) and small (B737) aircraft cases. O.C.

A91-22319
DERIVATION OF A FUSELAGE WEIGHT ESTIMATING RELATIONSHIP
PAUL W. SCOTT and JOHN L. NOVELLI (Douglas Aircraft Co., Long Beach, CA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 15 p.
(SAWE PAPER 1901) Copyright

A step-by-step developmental recapitulation is presented for an aircraft weight estimating relationship (WER) whose derivation is sufficiently close to being generic for application to a variety of vehicular structures. The WER proceeds by (1) establishing a preliminary plan; (2) normalizing the data base; (3) developing the preliminary WER; and (4) refining the WER. A fuselage weight-estimation relationship possessing 11 independent variables has in this way been derived and shown to demonstrate exceptionally high correlation with the fuselage weights of 12 different military transports whose gross weights range from 12,000 to 331,000 kg. O.C.

A91-22320
ANALYTICAL WEIGHT ESTIMATION OF UNCONVENTIONAL LANDING GEAR DESIGNS
ROBERT H. WILLE (McDonnell Douglas Corp., Saint Louis, MO) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 15 p.
(SAWE PAPER 1905) Copyright

Currently available military aircraft landing gear statistical weight-estimation equations may be inadequate for the unconventional variations in geometry and performance requirements associated with stealthy and high maneuverability configurations. Analytical weight estimates are inherently more sensitive than statistical ones to landing gear design variations. This analytical approach is embodied in Kraus' (1970) LANGE program, which is presently expanded to achieve greater analytical flexibility for the estimation of naval (carrier-based) landing-gear loading specifications as well as greater accuracy. Attention is given to the illustrative case of the F/A-18's main landing gear weight optimization process. O.C.

A91-22321
ROTORCRAFT STRUCTURAL WEIGHT AND COST ASPECTS
W. Z. STEPNIEWSKI SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 13 p. refs
(SAWE PAPER 1908) Copyright

An exploration is presented of the links between helicopter structural weight and cost. A reduction in structural weight, even is obtained only through a higher cost/lb of structure, as is often the case with advanced composite airframes, can yield a substantial lowering of total operating costs/revenue seat-mile for passenger carriage (or per revenue ton-mile in the case of cargo helicopters). When composites form a substantial portion of a helicopter's structural weight, various fatigue and environmental effects-related factors must be factored into the various weight-and-cost considerations. O.C.

A91-22326
ALUMINUM LITHIUM FOR THE F/A-18, HORNET 2000
JON C. JOHNSON (McDonnell Aircraft Co., Saint Louis, MO) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 38 p.
(SAWE PAPER 1913) Copyright

The 'Hornet 2000' derivative of the current F/A-18 will experience a 20-percent increase in empty weight due to avionics upgrades, survivability improvements, and wingspan and fuselage length increases; these changes have compelled consideration of Al-Li structures' incorporation for weight minimization without structural performance reduction. Data were merged from a structural drawings data base and an alloy weight data base, in order to arrive at a detailed listing of structural components potentially changeable into Al-Li; potential weight savings were then projected on the basis of a 9 percent alloy density reduction, together with ultimate Hornet 2000 empty weight savings. O.C.

A91-22327
ROTORCRAFT WEIGHT TRENDS IN LIGHT OF STRUCTURAL MATERIAL CHARACTERISTICS
W. Z. STEPNIEWSKI (International Technical Associates, Ltd., Upper Darby, PA) and C. C. INGALLS (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 35 p. refs
(SAWE PAPER 1873) Copyright

Variations in the weights of rotorcraft and their components due to advanced materials use are the topic of this study. The impact of new materials on component weights is illustrated by historical weight trends. The influence of structural material characteristics on the relative weight levels of rotorcraft components, the weight effectiveness, for both static and cyclical loadings is reviewed. Cursory expressions are developed to permit estimation of the effect of structural material strength effectiveness values on component relative weights. Special constraints which could limit possible weight reductions are considered briefly. Advanced structural materials that exhibit superior weight reduction potential are identified. Author

A91-22354#
THE FUZZY SYNTHETIC JUDGEMENT OF CORRELATING PARAMETER OF FIGHTER DESIGN
HONG CUI and YONG ZHAO (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, July 1990, p. A328-A332. In Chinese, with abstract in English. refs

Correlating parameters are developed which can be used to synthetically express the close combat maneuverability of fighters by the method of fuzzy mathematics. On the basis of analysis of fighter maneuvering performances, this paper proposes the parameters omega(A), omega(s), and SEP to measure the maneuvering performance. The linear weighted method, which is one of the basic methods of transforming several objects to a single object in mathematical programming, is used to determine the form of the correlating parameter expression. To determine the weight coefficients of maneuvering performance in the expression, the inverse problem of synthetic judgment in fuzzy mathematics is employed. The development of the equation of fuzzy relationship is based on judgment data gathered from many experts working in aeronautical field. The expression developed can be used in aircraft conceptual design and to judge synthetic measurements of maneuverability. Author

A91-22357#
NONLINEAR MULTI-POINT MODELING AND PARAMETER ESTIMATION OF THE DO 28 RESEARCH AIRCRAFT
WEI WANG, XINHAI CHEN, SHUNDA XIAO (Northwestern Polytechnical University, Xian, People's Republic of China), and R. BROCKHAUS (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, July 1990, p. A351-A359. In Chinese, with abstract in English. refs

The modeling and parameter estimation of the DO 28 research aircraft is a part of the German special research program 212 on air-traffic safety. In this paper a nonlinear multipoint mathematical model with six degrees of freedom for DO 28 parameter estimation is presented. The model considers the high nonlinearity of aircraft motions; the characteristics of the propeller, the wings, and the horizontal stabilizer; and the wind disturbance. Its features include reconstruction of a quasi-stationary windfield, an improved algorithm for thrust calculation, and the necessary corrections of the measured input/output signals through flight-test-data compatibility check. A nonlinear maximum-likelihood method and a modified Newton-Raphson optimization algorithm are applied to the estimation of the stability and control derivatives of the DO 28 aircraft. Compared with a one-point model of aircraft motion, it is shown that the multipoint model can more accurately describe the aircraft motion and is more suitable for aircraft parameter estimation. Author

A91-22381#
A METHOD OF DEVELOPING LOAD SPECTRUM FOR A FIGHTER AIRCRAFT
ZHI WANG, SHUWEN LI, and WENQI LIU (Air Force PR China, 1st Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B393-B395. In Chinese, with abstract in English.

This paper describes a method for developing load spectrum for fighter aircraft based on maneuvers. By using this method, the magnitude and the frequency of occurrence of loads experienced by fighter aircraft can be simulated. In addition, the sequence and distribution of loads can be represented. Author

A91-22757#
THE COMPATIBILITY CHECK OF THE FLIGHT TEST DATA OF THE DO 28 RESEARCH AIRCRAFT
WEI WANG, SHUNDA XIAO, XINHAI CHEN (Northwestern Polytechnical University, Xian, People's Republic of China), and R. BROCKHAUS (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A465-A473. In Chinese, with abstract in English. refs

The compatibility check and error corrections of flight test data from Dornier DO 28 research aircraft are discussed. A nonlinear six-DOF kinematic multipoint mathematical model with correction algorithms is presented. The wind-speed vector, angle of attack, and sideslip angle at any local point are successfully reconstructed by building a quasi-stationary wind field model. The relative time delays of all measured input/output signals are estimated with adequate precision using the equivalent first-order lag time constants. The measured heading, including discontinuous points, is appropriately transformed into a continuous signal, and the measured errors in angular velocity caused by sensor saturation are compensated for by the method. C.D.

A91-22956*# Massachusetts Inst. of Tech., Cambridge.
HIGH PERFORMANCE LINEAR-QUADRATIC AND H-INFINITY DESIGNS FOR A 'SUPERMANEUVERABLE' AIRCRAFT
LENA VALAVANI (MIT, Cambridge, MA) and PETROS VOULGARIS Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 157-165. Previously cited in issue 23, p. 3614, Accession no. A89-52712. refs
(Contract F08635-87-K-0031; NAG2-297)
Copyright

A91-23549
PREDICTION OF THE DYNAMIC CHARACTERISTICS OF HELICOPTERS IN CONSTRAINED FLIGHT
D. G. THOMSON and R. BRADLEY (Glasgow, University, Scotland) Aeronautical Journal (ISSN 0001-9240), vol. 94, Dec. 1990, p. 344-354. refs
Copyright

In circumstances where a pilot is forced to follow a specified flight path, such as during a landing approach or in nap-of-the-earth conditions, it will be shown that there is an apparent modification of the helicopter's stability characteristics. This effect is identified in helicopter flight data from nap-of-the-earth agility trials where oscillations are observed in the time histories or the pilot's control inputs and the vehicle's response. A technique of predicting the nature of these oscillations using a linearized helicopter mathematical model is developed. The model is inverted to give the response of the unconstrained states in terms of those strongly controlled by the need to remain on a specific flight path. Results are compared with data from flight trials and it is shown that good correlation between the period of the oscillations in the flight data and the predicted values can be obtained. Author

A91-23643#
INTRODUCTION TO THE BASIC TECHNOLOGY OF STEALTH AIRCRAFT. I - BASIC CONSIDERATIONS AND AIRCRAFT SELF-EMITTED SIGNALS (PASSIVE CONSIDERATIONS). II - ILLUMINATION BY THE ENEMY (ACTIVE CONSIDERATIONS)
D. HOWE (Cranfield Institute of Technology, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 75-86. refs
(ASME PAPER 90-GT-116; ASME PAPER 90-GT-117) Copyright

An account is given, first, of the signals potentially usable by an enemy in the detection and tracking of aircraft by passive means; these encompass acoustic, IR, visual, and other self-emitted phenomena. Attention is given to the means of either reducing the intensity of these emissions or eliminating them altogether. An evaluation is then made of the principles and development status of techniques for the reduction of probability of detection by such active means as radar. These techniques encompass the tailoring of several potential contributors to radar cross-section, as well as the incorporation of radar absorbers over external surfaces. The positive contributions obtainable through detailed design are noted. O.C.

A91-23644*# McDonnell Aircraft Co., Saint Louis, MO.
OPTIMIZING AIRCRAFT PERFORMANCE WITH ADAPTIVE, INTEGRATED FLIGHT/PROPULSION CONTROL
R. H. SMITH, J. D. CHISHOLM (McDonnell Aircraft Co., Saint Louis, MO), and J. F. STEWART (NASA, Flight Research Center, Edwards, CA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 87-94. refs
(ASME PAPER 90-GT-252) Copyright

The Performance-Seeking Control (PSC) integrated flight/propulsion adaptive control algorithm presented was developed in order to optimize total aircraft performance during steady-state engine operation. The PSC multimode algorithm minimizes fuel consumption at cruise conditions, while maximizing excess thrust during aircraft accelerations, climbs, and dashes, and simultaneously extending engine service life through reduction of fan-driving turbine inlet temperature upon engagement of the extended-life mode. The engine models incorporated by the PSC are continually upgraded, using a Kalman filter to detect anomalous operations. The PSC algorithm will be flight-demonstrated by an F-15 at NASA-Dryden. O.C.

A91-24119
ISHIDA TILT-WING PROJECT TAKES CUES FROM HISTORY
IWAO NAKATANI Vertiflite (ISSN 0042-4455), vol. 37, Jan.-Feb. 1991, p. 24-28.
Copyright

Ishida's plans for the testing, certification, and delivery of the TW-68 are discussed. The aircraft's potential use as a means of public transportation is cited as an important advantage and chief motive for its development. A historical overview is presented of the development of the tilt-wing aircraft, which began in the 1950s, noting that the Ishida Group included all previous tilt-wing programs in their overall analysis prior to selecting an aircraft design for development. A chart presents information considered in this analysis including first flight dates, operational dates, gross weight of the VTOL/STOL, and project scope for various aircraft company tilt-wing projects. The TW-68 will be powered by four turboprop

engines from the PT-6 family in two twin engine nacelles. Present design requirements and target markets are cited. L.K.S.

N91-15145# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
INTEGRATED DESIGN ANALYSIS AND OPTIMIZATION
G. SCHNEIDER, H. KRAMMER, and H. GOEDEL Apr. 1990 66 p Presented at 70th SMP Meeting on Integrated Design Analysis and Optimization: Preliminary Results Fin Optimization, Sorrento, Italy, Apr. 1990
(MBB/FE2/S/PUB/0398; ETN-90-98154) Copyright Avail: NTIS HC/MF A04

The current status is presented of MBB activities contributing to the AGARD working group, integrated design analysis, and optimization. For this research activity, MBB has proposed a fin design study with high aeroelastic and flutter design requirements, which was developed in 1983. A repetition of this design study using the MBB LAGRANGE program revealed the capability of a modern design tool. The results of an optimization run covering strength, aeroelastic, and flutter design constraints are documented. Starting from an initial design with violated design constraints, the optimization procedure ended with a lower structural weight, fulfilling all design constraints. ESA

N91-15146*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
REVIEW OF THE TRANSMISSIONS OF THE SOVIET HELICOPTERS
LEV I. CHAIKO Dec. 1990 14 p Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-103634; E-5803; NAS 1.15:103634; AVSCOM-TM-90-C-015) Avail: NTIS HC/MF A03 CSCL 01C

A review of the following aspects of Soviet helicopter transmissions is presented: transmitted power, weight, reduction ratio, RPM, design configuration, comparison of different type of manufacturing methods, and a description of the materials and technologies applied to critical transmission components. Included are mechanical diagrams of the gearboxes of the Soviet helicopters and test stands for testing gearbox and main shaft. The quality of Soviet helicopter transmissions and their Western counterparts are assessed and compared. Author

N91-15147*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATED ROTOR TEST APPARATUS DYNAMIC CHARACTERISTICS IN THE 80- BY 120-FOOT WIND TUNNEL
M. S. HOQUE (Sterling Federal Systems, Inc., Palo Alto, CA.), R. L. PETERSON, and T. A. GRAHAM Nov. 1990 23 p
(NASA-TM-102870; A-90301; NAS 1.15:102870) Avail: NTIS HC/MF A03 CSCL 01C

A shake test was conducted in the 80 by 120 foot Wind Tunnel at NASA Ames Research Center, using a load frame and dummy weights to simulate the weight of the NASA Rotor Test Apparatus. The simulated hub was excited with broadband random excitation, and accelerometer responses were measured at various locations. The transfer functions (acceleration per unit excitation force as a function of frequency) for each of the accelerometer responses were computed, and the data were analyzed using modal analysis to estimate the model parameters. Author

N91-15148# Battelle Columbus Labs., Research Triangle Park, NC.
AN EVALUATION OF SHAPE METHODS FOR HELICOPTER CLASSIFICATION AND ORIENTATION DETERMINATION Final Report, 7 Jul. 1987 - 31 Mar. 1988
TIMOTHY A. GROGAN (Cincinnati Univ., OH.) Sep. 1990 93 p
(Contract DAAG29-81-D-0100)
(AD-A227326; AD-E402098; ARFSD-CR-90016) Avail: NTIS HC/MF A05 CSCL 01/3

The performance of two competing methods are evaluated for classification and orientation determination accuracy. Helicopter fuselage silhouettes are classified as to their type and orientation. The methods are tested for sensitivity to imaging noise and the reference library sampling density. Under all conditions of imaging noise and library sampling density, the Fourier descriptor method out performs the Walsh points method for helicopter type classification. Helicopter type classification performance for the Fourier method ranges from 99 to 84 percent even under the most severe conditions examined. In almost all cases, the Fourier method exhibits median angle errors one-half those of the Walsh points method. Median angle errors of one-half the library sampling interval have been attained using the Fourier descriptor method. A scheme for helicopter rotor segmentation and orientation determination including the necessary additional library enhancements is also proposed. GRA

N91-15149# Naval Postgraduate School, Monterey, CA.
AIRCRAFT CONFIGURATION STUDY FOR EXPERIMENTAL 2-PLACE AIRCRAFT AND RPVS M.S. Thesis
GARY D. BLACK Mar. 1990 135 p
(AD-A227604) Avail: NTIS HC/MF A07 CSCL 01/1

A performance comparison and tradeoff study was conducted between eight unique aircraft configurations for high performance light aircraft and remotely piloted vehicles. These configurations included conventional tractor, conventional pusher, canard, tandem-wing, joined-wing, and 3-surface designs, which were analyzed though the use of microcomputer-based performance and lattice-vortex programs. Actual experimental aircraft were utilized as models which were scaled to a useful load of 600 pounds and given a common powerplant of 115 horsepower. The joined-wing, tandem-wing, and conventional pusher were found to exhibit sufficient improvement over a conventional tractor configuration to warrant serious consideration for design selection. The performance and stability programs provided reasonably accurate predictions of aircraft performance when given actual aircraft dimensions and power available data and warrant use for preliminary aircraft design. GRA

N91-15150# Oklahoma City Air Logistics Center, Tinker AFB, OK.
PROCEEDINGS OF THE 2ND E-3 AWACS CORROSION PREVENTION ADVISORY BOARD (CPAB)
12 Jul. 1990 141 p Meeting held at Tinker AFB, OK, 12 Jul. 1990
(AD-A227627) Avail: NTIS HC/MF A07 CSCL 11/3

Two environmental issues in particular are affecting all USAF weapons systems and is being felt by FMS weapons systems as well (particularly in Germany). These are volatile organic compounds (VOCs), and non-chemical paint removal. Topics include: problems with waterborne primers, MIL-P-85582; comparison of plastic materials, MIL-P-85891 (Dupont lease agreement); use of high solids polyurethane topcoat, MIL-C-85285; and qualification of materials. GRA

N91-15151 ESDU International Ltd., London (England).
ENERGY HEIGHT METHOD FOR FLIGHT PATH OPTIMISATION Abstract Only
Jul. 1990 32 p Supersedes ESDU-Perf-EG3/3; ESDU-Perf-EG3/4; ESDU-Perf-EG3/5
(ESDU-90012; ESDU-PERF-EG3/3; ESDU-PERF-EG3/4; ESDU-PERF-EG3/5; ISBN-0-85679-738-3; ISSN-0141-4054)
Avail: ESDU

ESDU 90012 discusses and illustrates the use of the energy height method to minimize time or fuel used in transferring from one (velocity, height) point to another. Energy height is an equivalent height that yields an equivalent potential energy at any point equal to the sum of the kinetic and true potential energies of the aircraft. The method allows additional constraints to be applied, such as structural or aerodynamic limits (for example, maximum Mach number or lift coefficient) or operational limits (for example, horizontal distance coverage in the climb). It involves the simplifications that net thrust is assumed always to be aligned with the flight path and that drag equals drag in level flight at the given weight irrespective of aircraft attitude or maneuvers. In addition, transfers between trajectories are assumed instantaneous.

The effect of these assumptions is studied and shown to be generally small for a range of typical aircraft configurations. Four worked examples illustrate the use of the method: for a combat aircraft minimum time to height and speed, and to height, speed, and distance, and for a subsonic transport aircraft minimum fuel to height and speed, and to height, speed, and distance. ESDU

N91-15152 ESDU International Ltd., London (England).
NORMAL FORCE AND PITCHING MOMENT OF LOW ASPECT RATIO CROPPED-DELTA WINGS UP TO HIGH ANGLES OF ATTACK AT SUPERSONIC SPEEDS Abstract Only
Aug. 1990 17 p
(ESDU-90013; ISBN-0-85679-739-1; ISSN-0141-397X) Avail: ESDU

ESDU 90013 gives a semi-empirical method for thin uncambered and untwisted wings with streamwise or pointed tips and sharp leading-edges and unswept sharp trailing-edges. It applies for angles of attack up to 60 degrees and for Mach numbers from 1.2 to 5. The method requires only the aspect and taper ratios, together with values at zero angle of attack of normal-force-curve slope and aerodynamic center position which may be obtained from ESDU 70012. The method was developed from a correlation of published and unpublished experimental data for taper ratios less that 0.5 and aspect ratios of 0.5 to 4 while for taper ratios exceeding 0.5 the aspect ratios were from 0.5 to 2; however, for angles of attack less than 20 degrees, the aspect ratio went down to 0.2. It predicted the normal force coefficient to within 10 percent except at low angles of attack where the accuracy was determined by ESDU 70012 and was within 15 percent and gave aerodynamic center position as a fraction of aerodynamic mean chord to within 0.05 which yielded a pitching moment coefficient, based on root chord, within 0.03. Although all the data are for monoplane wings, it is suggested the results will apply to a cruciform configuration in symmetric flight with one wing in the plane of symmetry. The use of the method is illustrated with a worked example. ESDU

N91-15153# Wichita State Univ., KS. National Inst. for Aviation Research.
RESIN TRANSFER MOLDING OF COMPOSITE AIRCRAFT INTERIOR FURNISHINGS
MARK WADSWORTH Jun. 1990 14 p Presented at the Aircraft Interiors Conference, Wichita, KS, 24-25 Apr. 1990
(NIAR-90-19) Avail: NTIS HC/MF A03

The main objectives were to develop a low cost fabrication system for aircraft interior furnishing with the following characteristics: (1) must meet the FAA flammability regulations; (2) must have the potential for application to the new commercial aircraft flammability requirements; (3) utilize low cost tooling; (4) the weight must be reduced over current designs; (5) minimum tooling costs since low quantities are usually built; (6) the furnishing must have aesthetic appeal; and (7) components must withstand 9 gravity forces without damage. Each of these criteria was analyzed in the context of improved producibility. Y.S.

N91-16006 Maryland Univ., College Park.
A COUPLED ROTOR AEROELASTIC ANALYSIS UTILIZING ADVANCED AERODYNAMIC MODELING Ph.D. Thesis
MICHAEL SCOTT TOROK 1989 339 p
Avail: Univ. Microfilms Order No. DA9021593

The effects of improved aerodynamic modeling on rotor blade section and root loads, blade response, and blade stability are investigated. A nonlinear unsteady aerodynamic model for attached and separated flow and dynamic stall, as well as prescribed and free wake models, are incorporated into a coupled rotor aeroelastic analysis. Blade responses and loadings are calculated using a finite element formulation in space and time. A modified Newton iterative method is used to calculate blade response and trim controls as one coupled solution. Aeroelastic stability is determined utilizing Floquet theory for a linearized system, and a transient perturbation technique which can model nonlinear unsteady aerodynamic effects. Damping estimations are made using a Moving-Block analysis. Results of a parametric study of a soft in-plane hingeless rotor show that at high speed flight conditions, nonlinear effects dominate blade section forces, and significantly affect peak-to-peak values and the harmonic content of blade root loads. A correlation with SA349/2 Aerospatiale Gazelle flight test data is used to evaluate the analysis. Trim controls, blade section aerodynamic loads, and blade flap bending moments are satisfactorily predicted. The rotor stability analysis is correlated with model hingeless rotor data. A parametric study of a hingeless rotor in forward flight is examined. Dissert. Abstr.

N91-16007# Army Lab. Command, Watertown, MA. Material Technology Lab.
FAILURE ANALYSIS OF A MAIN ROTOR PITCH HORN BOLT LOCATED ON THE AH-1 COBRA HELICOPTER Final Report
VICTOR K. CHAMPAGNE, JR. Sep. 1990 36 p
(AD-A227679; MTL-TR-90-44) Avail: NTIS HC/MF A03 CSCL 01/3

A comprehensive metallurgical examination of the pitch horn bolt was conducted to determine the probable cause of failure. The component is part of the main rotor hub assembly and had failed while in service. Light optical microscopy revealed evidence of corrosion pitting in regions adjacent to the fracture. Chemical analysis verified that the part was fabricated from 4340 steel. It was determined by metallographic examination that the microstructure was tempered martensite. Hardness measurements taken on transverse cross sections of the bolt near the fracture indicated that the material had been hardened to the upper limit of the specified range. The surface finish was measured along the upper shank and conformed to the requirements of the engineering drawing. Fractographic examination utilizing the scanning electron microscope (SEM) revealed multiple crack origins which assumed a decohesion. Many of these crack sites were initiated from corrosion pits. Energy dispersing spectroscopy (EDS) performed on areas within the crack initiation site showed the presence of chlorides. Beyond the thumbnail zone fast fracture occurred in a ductile manner, which was confirmed by a dimpled topography. The failure was attributed to stress corrosion cracking (SCC). GRA

N91-16010*# Rice Univ., Houston, TX. Dept. of Mechanical Engineering and Materials Science.
OPTIMIZATION AND GUIDANCE OF FLIGHT TRAJECTORIES FOR THE NATIONAL AEROSPACE PLANE Final Report, 22 Jun. 1989 - 31 Dec. 1990
ANGELO MIELE 1990 22 p
(Contract NAG1-1029)
(NASA-CR-187837; NAS 1.26:187837; AAR-252) Avail: NTIS HC/MF A03 CSCL 01/3

The research on optimal trajectories for the National Aerospace Plane (NASP) performed by the Aero-Astronautics Group of Rice University from June 22, 1989 to December 31, 1990 is summarized. The aerospace plane is assumed to be controlled via the angle of attack and the power setting. The time history of the controls is optimized simultaneously with the switch times from one powerplant to another and the final time. The intent is to arrive at NASP guidance trajectories exhibiting many of the desirable characteristics of NASP optimal trajectories. Author

N91-16011*# Rice Univ., Houston, TX. Dept. of Mechanical Engineering and Materials Science.
OPTIMAL TRAJECTORIES FOR AN AEROSPACE PLANE. PART 2: DATA, TABLES, AND GRAPHS
ANGELO MIELE, W. Y. LEE, and G. D. WU 1990 94 p Presented at the 1990 American Control Conference, San Diego, CA, 23-25 May 1990
(Contract NAG1-1029)
(NASA-CR-187848; NAS 1.26:187848; AAR-248-PT-2) Avail: NTIS HC/MF A05 CSCL 01/3

Data, tables, and graphs relative to the optimal trajectories for an aerospace plane are presented. A single-stage-to-orbit (SSTO) configuration is considered, and the transition from low supersonic speeds to orbital speeds is studied for a single aerodynamic model (GHAME) and three engine models. Four optimization problems

are solved using the sequential gradient-restoration algorithm for optimal control problems: (1) minimization of the weight of fuel consumed; (2) minimization of the peak dynamic pressure; (3) minimization of the peak heating rate; and (4) minimization of the peak tangential acceleration. The above optimization studies are carried out for different combinations of constraints, specifically: initial path inclination that is either free or given; dynamic pressure that is either free or bounded; and tangential acceleration that is either free or bounded. Author

N91-16012*# Purdue Univ., West Lafayette, IN. School of Mechanical Engineering.
APPLICATIONS OF FUZZY THEORIES TO MULTI-OBJECTIVE SYSTEM OPTIMIZATION
S. S. RAO and A. K. DHINGRA Jan. 1991 74 p
(Contract NCA2-223)
(NASA-CR-177573; A-91029; NAS 1.26:177573) Avail: NTIS HC/MF A04 CSCL 01/3

Most of the computer aided design techniques developed so far deal with the optimization of a single objective function over the feasible design space. However, there often exist several engineering design problems which require a simultaneous consideration of several objective functions. This work presents several techniques of multiobjective optimization. In addition, a new formulation, based on fuzzy theories, is also introduced for the solution of multiobjective system optimization problems. The fuzzy formulation is useful in dealing with systems which are described imprecisely using fuzzy terms such as, 'sufficiently large', 'very strong', or 'satisfactory'. The proposed theory translates the imprecise linguistic statements and multiple objectives into equivalent crisp mathematical statements using fuzzy logic. The effectiveness of all the methodologies and theories presented is illustrated by formulating and solving two different engineering design problems. The first one involves the flight trajectory optimization and the main rotor design of helicopters. The second one is concerned with the integrated kinematic-dynamic synthesis of planar mechanisms. The use and effectiveness of nonlinear membership functions in fuzzy formulation is also demonstrated. The numerical results indicate that the fuzzy formulation could yield results which are qualitatively different from those provided by the crisp formulation. It is felt that the fuzzy formulation will handle real life design problems on a more rational basis. Author

N91-16013*# Rice Univ., Houston, TX. Aero-Astronautics Group.
OPTIMAL TRAJECTORIES FOR AN AEROSPACE PLANE. PART 1: FORMULATION, RESULTS, AND ANALYSIS
ANGELO MIELE, W. Y. LEE, and G. D. WU 1990 61 p Presented at the American Control Conference, San Diego, CA, 23-25 May 1990
(Contract NAG1-1029; TATP-003604020)
(NASA-CR-187868; NAS 1.26:187868; AAR-247) Avail: NTIS HC/MF A04 CSCL 01/3

The optimization of the trajectories of an aerospace plane is discussed. This is a hypervelocity vehicle capable of achieving orbital speed, while taking off horizontally. The vehicle is propelled by four types of engines: turbojet engines for flight at subsonic speeds/low supersonic speeds; ramjet engines for flight at moderate supersonic speeds/low hypersonic speeds; scramjet engines for flight at hypersonic speeds; and rocket engines for flight at near-orbital speeds. A single-stage-to-orbit (SSTO) configuration is considered, and the transition from low supersonic speeds to orbital speeds is studied under the following assumptions: the turbojet portion of the trajectory has been completed; the aerospace plane is controlled via the angle of attack and the power setting; the aerodynamic model is the generic hypersonic aerodynamics model example (GHAME). Concerning the engine model, three options are considered: (EM1), a ramjet/scramjet combination in which the scramjet specific impulse tends to a nearly-constant value at large Mach numbers; (EM2), a ramjet/scramjet combination in which the scramjet specific impulse decreases monotonically at large Mach numbers; and (EM3), a ramjet/scramjet/rocket combination in which, owing to stagnation temperature limitations, the scramjet operates only at M approx. less than 15; at higher Mach numbers, the scramjet is shut off and the aerospace plane is driven only by the rocket engines. Under the above assumptions, four optimization problems are solved using the sequential gradient-restoration algorithm for optimal control problems: (P1) minimization of the weight of fuel consumed; (P2) minimization of the peak dynamic pressure; (P3) minimization of the peak heating rate; and (P4) minimization of the peak tangential acceleration. Author

N91-16014# Technische Univ., Brunswick (Germany, F.R.). Fakultaet fuer Maschinenbau und Elektrotechnik.
TESTS FOR INTEGRATING MEASUREMENTS OF GAS PRESSURES IN AIRCRAFT MECHANISMS Ph.D. Thesis [VERSUCHE ZUR INTEGRIERENDEN MESSUNG VON GASDRUECKEN IN FLUGTRIEBWERKEN]
GERARDO WALLE 1989 217 p In GERMAN
(ETN-91-98558) Avail: NTIS HC/MF A10

The possibility that the integral signal driven by a fiber is a measure for the mean value of the examined data, is studied. Examinations were carried out at a firmly inserted fiber, which was bent between two support teeth by a weight tooth (fiber deformation unity). The radial curvature distributions along the fiber was approximately simulated by the bend beam model. The relation between damping and bending was described by a nonlinear exponential function. For the practical realization of a sensor with optical fibers several prototypes were made and the conditions for a successful conception were defined. ESA

N91-16015# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft Div.
AEROTHERMODYNAMIC PHENOMENA AND THE DESIGN OF ATMOSPHERIC HYPERSONIC AIRPLANES
E. H. HIRSCHEL 18 Jul. 1990 42 p Presented at the 3rd Joint Europe/US Short Course in Hypersonics, Aachen, Fed. Republic of Germany, 1-5 Oct. 1990
(MBB/FE122/S/PUB/0408; ETN-91-98545) Avail: NTIS HC/MF A03

The design problems of aerodynamic hypersonic airplanes and the aerodynamic tools such as wind tunnels and computation methods are reviewed simultaneously with their validation problems. Aerodynamic phenomena such as viscosity, heat loads, heat transfer and real gas effects are studied with consideration of the design and simulation problems. It is remarked that research and development must be increased in the area of turbulence and laminar turbulent transition. ESA

N91-16016# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
HYPERSONIC MODEL CONFIGURATIONS
K. M. WANIE, ed. and E. H. HIRSCHEL 7 Aug. 1990 78 p In GERMAN; ENGLISH summary
(MBB/FE122/S/PUB/411; ETN-91-98546) Avail: NTIS HC/MF A05

Model configurations for the development of hypersonic aerothermodynamics are presented in order to create a common data base for hypersonic cruise flights. Each configuration is dedicated to a specific problem arising from the flight conditions. ESA

N91-16017# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Aircraft Div.
THE INTEGRATION OF STRUCTURAL OPTIMIZATION IN THE GENERAL DESIGN PROCESS FOR AIRCRAFT
O. SENSBURG, J. SCHWEIGER, H. GOEDEL, and A. LOTZE 21 Jun. 1990 12 p Presented at the 17th Congress of the International Council of the Aeronautical Sciences, Stockholm, Sweden, 9-14 Sep. 1990
(MBB/FE122/S/PUB/0405; ETN-91-98547) Copyright Avail: NTIS HC/MF A03

A method for solving large linear equation systems by an iterative method is described and successfully applied with the

MBB-LAGRANGE code which uses mathematical programming and gradients to fulfill different constraints simultaneously. As examples, heat flux and frequency optimization of a satellite structure, and design of a carbon fiber wing are presented and studied with the finite element method. In the first case, vector optimization method is added to obtain a compromise solution between dynamic and thermal constraints. ESA

N91-16018# Cranfield Inst. of Tech., Bedford (England). Dept. of Aerospace Vehicle Design.
TF89 AIRCRAFT CENTRE FUSELAGE M.S. Thesis
D. C. ELLIS Apr. 1990 248 p
(ETN-91-98579) Copyright Avail: NTIS HC/MF A11

The design work undertaken on the TF89 tactical fighter aircraft center fuselage is detailed. The requirement is for a high performance, long range interceptor, comparable to the American Tactical Fighter (ATF) project, to replace the now ageing F15. Maneuver shear force and bending moment loading analyses of the fuselage are presented with explanations of longeron design using the computer program STRUCT and skin design. A fatigue analysis of a longeron is undertaken. The design solution uses aluminum lithium alloy throughout. ESA

N91-16019# Cranfield Inst. of Tech., Bedford (England). Dept. of Aircraft Design.
TF89 TACTICAL FIGHTER OUTER WING DESIGN M.S. Thesis
A. M. LEAHY May 1990 230 p
(ETN-91-98580) Copyright Avail: NTIS HC/MF A11

The swept wing is largely designed using thermoplastic PEEK (PolyEtherEtherKetone) composite material which offers excellent specific strength, good fracture toughness and can be tailored to match the wing loading. A highly redundant multiple spar structure is used to meet the chosen failsafe design philosophy. The wing skins carry both shear and some bending and hence are reinforced by closely spaced spanwise stiffeners which prevent buckling. The wing was modeled on the finite element system to obtain the distribution of the loads though the structure. All detailed discussion and calculations are shown, as well as stress calculations and drawings. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A91-20609
HOW SAFE IS FLYING? OR - THE AIMS ONBOARD INTEGRATED MONITORING SYSTEMS [WIE SICHER IST DAS FLIEGEN? ODER - BORDINTEGRIERTE UEBERWACHUNGSSYSTEME AIMS]
HELMUT HARDEGEN (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 2-5. In German. refs
Copyright

The development and applications of AIMS (Aircraft Integrated Monitoring System) are briefly discussed. The use of AIMS in monitoring aircraft engines, avionics, pilot/aircraft interaction, failures, and shear wind effects are considered. The cost-benefit aspects of AIMS are addressed. C.D.

A91-20617
COMPUTER COMMUNICATION USING LOGIC CELL ARRAYS (LCA) IN ATTAS [RECHNER-KOMMUNIKATION UNTER VERWENDUNG VON LOGIC CELL ARRAYS /LCA/ AM BEISPIEL ATTAS]
HANS-PETER SCHWANECK (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 45-47. In German.
Copyright

A new hardware for computer communication has been developed for the computer network onboard ATTAS (Advanced Technologies Testing Aircraft). The hardware uses highly integrated, programmable elements called Logic Cell Arrays (LCA). The programmable logic components and the LCA design cycle are described, and the realization of the system is discussed. C.D.

A91-20982
ARTIST - AIRBORNE REAL TIME INSTRUMENTATION SYSTEM
F. X. SUDHARMONO, M. MULIA TIRTOSUDIRO, and MR. SRIYONO (Nusantara Aircraft Industries, Ltd., Bandung, Indonesia) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2A.2-1 to 2A.2-8. refs
Copyright

A novel system is being introduced for performing test flights in Indonesia where telemetry data transmission could not be assured due to the terrain limitations and the extreme distance of the test area to the base. This ARTISt system is capable of producing data in real-time in the form of barcharts, graphics, tables, and a mixture of graphics and tables to give the engineer on board an impression of the flight test situation being performed. The definition of the global parameters set is controlled by a module, GLODEF, which provides three functions: (1) GLOSHO, which shows what parameters are included in a global parameters set file; (2) GLOINI, which sets up and initiates the ARTISt system and allows the operator to select which global parameter set is to be utilized; and (3) CALMOD, which defines the format of the test area. The test data can be processed in the form of electrical units (raw data) or engineering units. R.E.P.

A91-21221
VASI SYSTEMS FOR HELICOPTER OPERATIONS
C. DEVASENAPATHY (International Civil Aviation Organization, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 45, Aug. 1990, p. 6-8.
Copyright

This paper sums up the ICAO developed specifications on the visual approach slope indicator (VASI) systems for helicopter operations. These systems include the precision approach path indicator (PAPI), an abbreviated configuration of PAPI (APAPI), and a new single-unit system, designated the helicopter approach path indicator (HAPI), which was specifically designed for helicopter operations. HAPI specifications including equipment characteristics, filter characteristics, system installation, initial flight inspection, and routine inspections are described. The HAPI is best suited for operation on a floating helideck, where its signal remains stable despite the pitching and rolling motions of the helideck. R.E.P.

A91-21248
INTEGRATED CONTROL AND AVIONICS FOR AIR SUPERIORITY - A PROGRAM OVERVIEW
JAMES A. KOCHER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 11 p. refs
(SAE PAPER 901049) Copyright

Potentially critical technologies enabling prospective USAF fighter aircraft to survive air combat engagements in which they are outnumbered by enemy aircraft are the focus of the Integrated Control and Avionics for Air Superiority (ICAAS) program. ICAAS has as its goal the securing of victories when USAF fighters are outnumbered 4:1, with such technological capabilities anticipated for the 1995-2000 as beyond-visual-range multiple target attack and smooth transition to close-in combat. Sufficient integration and automation will be furnished for such taxing targeting tasks' implementation in a single-seat fighter; an intraflight data link is included to enhance mutual combat support among USAF fighters. O.C.

A91-22202#
CONTROL CONCEPT OF MODERN AVIONICS IN THE SERVICE OF PILOT RELIEF - PRESENTED USING THE EXAMPLE OF DO 328 [KONTROLLKONZEPT MODERNER AVIONIK IM DIENST DER PILOTENENTLASTUNG - DARGESTELLT AM BEISPIEL DER DO 328]
H. FEUERSENGER (Dornier Luftfahrt GmbH, Wessling, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 3, 1990, p. 360-371. In German.

The avionics system used in the DO 328 is discussed. An avionics control concept using 'soft keys' is described, including the automatic monitoring of the flight configuration, the allowable flight regime, the performance, and the overall system. The avionics control menus are shown along with flight displays. C.D.

A91-22301
HELICOPTER WEIGHT AND TORQUE ADVISORY SYSTEM
RICHARD L. ADELSON (Boeing Military Airplanes, Wichita, KS) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 11 p.
(SAWE PAPER 1872) Copyright

The Weight and Torque Advisory (WTA) system for helicopters presented is an onboard avionic system which assists pilots in the definition of maximum cargo-carrying capability while enhancing safety, reducing maintenance costs, and extending helicopter service life. The WTA combines cargo-hook load weight information with temperature, altitude, and fuel weight for the computation of optimum performance data which can be displayed for the pilots on the cockpit instrument board. All WTA system features are generic, thereby allowing adaptation to different types of helicopters; the WTA may also be used with other avionic system components or operate as a stand-alone system with its own dedicated processor, control panel, and display. O.C.

A91-23134 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
AIRBORNE LIDAR FOR PROFILING OF SURFACE TOPOGRAPHY
JACK L. BUFTON, JAMES B. GARVIN, JOHN F. CAVANAUGH, LUIS RAMOS-IZQUIERDO (NASA, Goddard Space Flight Center, Greenbelt, MD), THOMAS D. CLEM, and WILLIAM B. KRABILL (NASA, Wallops Flight Center, Wallops Island, VA) Optical Engineering (ISSN 0091-3286), vol. 30, Jan. 1991, p. 72-78. refs
Copyright

A lidar system is described that measures laser pulse time-of-flight and the distortion of the pulse waveform for reflection from earth surface terrain features. This instrument system is mounted on a high-altitude aircraft platform and operated in a repetitively pulsed mode for measurements of surface elevation profiles. The laser transmitter makes use of recently developed short-pulse diode-pumped solid-state laser technology. Aircraft position in three dimensions is measured to submeter accuracy by use of differential Global Positioning System receivers. Instrument construction and performance are detailed. Author

A91-24095
HIGH-PRECISION FIBER-OPTIC POSITION SENSING USING DIODE LASER RADAR TECHNIQUES
GREGORY L. ABBAS, W. RANDALL BABBITT, MICHAEL DE LA CHAPELLE, MARK L. FLESHNER, J. DOYLE MCCLURE (Boeing Aerospace and Electronics High Technology Center, Seattle, WA) et al. IN: Laser-diode technology and applications II; Proceedings of the Meeting, Los Angeles, CA, Jan. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 468-479. refs
Copyright

An account is given of analytical, design, and testing procedures for a linear position sensor that employs diode laser radar techniques in conjunction with fiber-optic signal distribution. A frequency-chirped and intensity-modulated semiconductor diode laser transmits, while the receiving sensors are a moving and a fixed reflector operating in a difference-ranging mode in order to cancel temperature-induced fiber-length variations. The performance of the laser radar position sensor is analyzed by calculating the return's S/N value; a Cramer-Rao lower bound is then derived in order to relate the SNR, chirp bandwidth, and chirp duration to the rms range error. The theoretical optimum performance of the sensor system was 58 microns rms range error, on the basis of a chirp duration with 50-microsec processing time. O.C.

N91-15154# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
ADVANCES IN COMPONENTS FOR ACTIVE AND PASSIVE AIRBORNE SENSORS
Sep. 1990 191 p Meeting held in Bath, England, 9-10 May 1990
(AGARD-CP-482; ISBN-92-835-0584-0) Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The survivability of aircraft and their capability of carrying out different missions rely on numerous sensor systems such as radar, altimeters, radio navigation, measure, and countermeasure equipment. It is very important that the most advanced semiconductor technologies be used in those systems as early as possible because avionic equipment performance is limited by the available components. Emerging semiconductor components and sensor technologies are examined in the proceedings from this workshop.

N91-15155# Thomson Composants, Saint Egreve (France). Militaires et Spatiaux.
SPECIFIC ASPECTS OF ADVANCED COMPONENTS FOR AIRBORNE APPLICATIONS
JEAN-MICHEL BRICE *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 6 p Sep. 1990
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Some of the important specific aspects are presented of electronic components, mainly high speed, high performance integrated circuits used for airborne applications. It is shown that the requirements such as complexity, performance, power consumption, are more stringent for airborne components than for other components, civil ones in particular. In addition, the long lifetime of airborne equipments, typically 25 to 30 years, requires specific arrangement to assure the long term availability of the strategic components, as the semiconductor technologies don't survive more than 10 years. The antinomy, use of standard and mature technologies for low cost and large product base but necessity to get access to specific or advanced technologies for specific performance requirements, can be solved by the add-on military concept, where civil technologies are used whenever possible, but specific developments are undertaken to fulfill the military airborne specifications. Author

N91-15156# Thomson Composants, Orsay (France).
MICROWAVE AND MILLIMETER WAVE COMPONENTS: PERFORMANCES, PERSPECTIVES, AND APPLICATIONS TO AVIONICS
PIERRE BRIERE and DOMINIQUE PONS (Thomson-CSF, Orsay, France) *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 7 p Sep. 1990
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Significant advances in microwave and millimeter wave three terminal devices have been obtained in the last few years, leading to great performance gains in noise figure power gain, and power output up to 100 GHz. Great improvements in materials growth, heterojunction device structures and processing technology have resulted in noise figure as low as 1.4 dB and power output in excess of 50 mw, both at 94 GHz. In addition, the emergence of Heterojunction Bipolar Transistor (HBT) based Monolithic Microwave Integrated Circuit's (MMIC's) opens new possibilities for high power and high efficiency circuits, low phase noise Voltage Controlled Oscillators (VCOs) and others. The different types of these advanced devices are reviewed and their performance

characteristics in low noise and power applications are examined. Potential applications of such devices with their specific advantages in electronic airborne equipment are also studied. Author

N91-15159# Army Electronics Technology and Devices Lab., Fort Monmouth, NJ.
LOW-NOISE OSCILLATORS FOR AIRBORNE RADAR APPLICATIONS
RAYMOND L. FILLER and JOHN R. VIG *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 16 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Vibration effects are a significant problem in modern communication, navigation, and radar systems. Vibration induced phase noise can change the probability of detection of moving target indicator (MTI) radar from near 100 percent to 0. Oscillators that are capable of meeting the requirements of MTI radar systems in a quiet environment are readily available. In the vibrating environments of airborne platforms, however, the phase noise of oscillators will degrade to a large degree. High stability frequency sources, including atomic standards, contain quartz crystal resonators. One result of the evolution of electronics, i.e., the transition from tubes to transistors, and from point-to-point wiring to printed circuits, is the establishment of the quartz crystal resonator as the most acceleration sensitive component in frequency sources. The causes and effects of acceleration sensitivity of bulkwave quartz crystal resonators are reviewed along with the methods that reduce or compensate for that sensitivity. Most of what is discussed is relevant to most microwave oscillators. Author

N91-15160# Siemens A.G., Munich (Germany, F.R.). Components Group.
GAAS MMICS IN SELFALIGNED GATE TECHNOLOGY FOR PHASED ARRAY RADAR APPLICATION
E. PETTENPAUL and U. FREYER (Siemens A.G., Unterschleissheim, Germany, F.R.) *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 10 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Design and performance data of GaAs Monolithic Microwave Integrated Circuits (MMICs) for C and X band Transmitter/Receiver (T/R) Radar Antenna Modules and broadband Electronic Countermeasure application are described. The devices considered are low noise amplifiers, medium power amplifiers, 3 W high power amplifiers, 4 and 6 bit attenuators, 4 and 6 bit phase shifters, and distributed amplifiers. The devices are fabricated on a high volume pilot line with only one standard high yield process. The main steps in the process are given. In comparison to other standard MMIC process lines it is specific, that a Selfaligned Gate Technique, the so called DIOM (Double Ge/Si contact Implantation, One Metallization) process, is used for production. Thereupon is another specific aspect that an advanced inhouse computer aided design package for GaAs MMICs and a very accurate cell library based on on-wafer RF measurements is operational. Highlights are the very accurate and low noise 6 bit attenuators and phase shifters and especially a high power amplifier MMIC with 3.6 W output power and 31 percent added efficiency at C band. Author

N91-15164# Naval Weapons Center, China Lake, CA.
LOGARITHMIC AMPLIFICATION FOR PASSIVE AIRBORNE DIRECTION FINDING IN THE 1990S
RICHARD SMITH HUGHES *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 15 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Logarithmic amplifiers (log amps) are indepensable parts in most airborne passive direction finding (DF) sensors, including both antiradiation missiles (ARMs) and radar warning receivers (RWRs) on aircraft. The modern early warning (EW) threat necessitates covering increased instantaneous radio frequency (RF) bandwidths and processing increasing pulse densities, coupled with needs for lower power dissipation, smaller size, and lower cost. Because of these constraints, the log amp designer is often at a loss. Successive detection log intermediate frequency amps (SDLAs) and Detector/log video amps (DLVAs) have disadvantages. The log amps of the 1970s through mid 80s will not meet the stringent requirement of the 90s. A historical perspective is presented of the why's and how's of modern log amps, with emphasis on their application specific strong and weak points. New circuit elements and topologies are presented that may well determine where the log amps of the 90s are headed. Author

N91-15166# Rome Air Development Center, Griffiss AFB, NY.
MMIC IMPACT ON AIRBORNE AVIONIC SYSTEMS
EDWARD J. JONES and WILLIAM J. BOCCHI, JR. *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 7 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The latest advances in Monolithic Microwave Integrated Circuit (MMIC) technology and its impact on airborne avionic systems, along with a unique technique for designing reliability into MMIC devices, is described. Current MMIC transmit/receive (T/R) module performance is presented along with current hybrid module results for comparison. For example, typical RMS phase error for a 10 GHz T/R MMIC module is about one half of a hybrid module, which can increase antenna performance by 5 dB. Work in developing and applying finite element analysis (FEA) techniques to MMIC T/R modules to determine temperature and stress levels within microscopic regions of these devices is also examined. It is now possible to assess the reliability of new MMIC designs using this analytical tool which makes it possible to avoid time consuming and costly after-the-fact test and redesign of a given development. Author

N91-15169# Naval Weapons Center, China Lake, CA. Targeting and Fire Control Div.
LASER OBSTACLE AND CABLE UPDATE SENSOR
C. K. BULLOCK, R. T. HINTZ, and W. TANAKA *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 21 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The real night foreign weapon evaluation (FWE) program was evaluating an integrated night attack avionics suite for an A-6E aircraft. The most recent addition to this avionics suite is a CO2 laser terrain following/obstacle avoidance (TF/OA) sensor. The requirements are described for this type of sensor along with the characteristics of the system, and some preliminary test results gathered during A-6 flights. Author

N91-15171# Aeronautical Research Labs., Melbourne (Australia).
PROGRAMMABLE COCKPIT-FLIGHT DYNAMIC MODEL
M. IOB Jul. 1990 24 p
(AD-A227748; ARL-SYS-TM-138; DODA-AR-006-078) Avail: NTIS HC/MF A03 CSCL 01/4

The programmable cockpit has been developed as a low cost alternative to a full research simulator. It is intended for use in cockpit display design and layout studies and for crew workload and other human factors studies. With this system it is possible to quickly change the design or layout of a display and evaluate it under representative flight conditions. A six degree of freedom flight dynamic model has been developed for the Programmable Cockpit. The model's development is described from it original form in the IBM PC-AT Simulator to its current implementation in the Programmable Cockpit. It features and operation are described in some detail as well as its limitations. A brief overview of the Programmable Cockpit is also given. The hardware required for the simulator includes: IBM PC-AT 80286 computer with 80287 mathematics co-processor; Locus System Engineering touch screen; MetraByte DASH-8 eight channel, 12 bit A/D converter;

and Measurement System Inc. analogue, spring-centered joystick. GRA

N91-15172# Aeronautical Research Labs., Melbourne (Australia).
PROGRAMMABLE COCKPIT-HEAD-UP DISPLAY AND OUTSIDE VIEW
ANDREW G. PAGE Jun. 1990 27 p
(AD-A227751; ARL-SYS-TM-137; DODA-AR-006-077) Avail: NTIS HC/MF A03 CSCL 17/5

The Programmable Cockpit is a low-cost facility utilizing personal computers linked together to represent the fundamental displays of a fixed-wing aircraft. The cockpit instruments can be displayed either in the conventional manner or in a glass-cockpit type format. Aircraft controls include a sidestick and throttle. It was designed so that the instrument layouts and display formats could be reconfigured rapidly and tested in a reasonable aircraft representation, with the pilot under representative workload conditions. The Programmable Cockpit is to be used to study and develop the pilot vehicle interface for future aircraft systems. GRA

N91-15173*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF SHAPING SENSOR DATA ON PILOT RESPONSE
ROGER M. BAILEY Nov. 1990 19 p
(NASA-TM-102737; NAS 1.15:102737) Avail: NTIS HC/MF A03 CSCL 01/4

The pilot of a modern jet aircraft is subjected to varying workloads while being responsible for multiple, ongoing tasks. The ability to associate the pilot's responses with the task/situation, by modifying the way information is presented relative to the task, could provide a means of reducing workload. To examine the feasibility of this concept, a real time simulation study was undertaken to determine whether preprocessing of sensor data would affect pilot response. Results indicated that preprocessing could be an effective way to tailor the pilot's response to displayed data. The effects of three transformations or shaping functions were evaluated with respect to the pilot's ability to predict and detect out-of-tolerance conditions while monitoring an electronic engine display. Two nonlinear transformations, on being the inverse of the other, were compared to a linear transformation. Results indicate that a nonlinear transformation that increases the rate-or-change of output relative to input tends to advance the prediction response and improve the detection response, while a nonlinear transformation that decreases the rate-of-change of output relative to input tends to lengthen the prediction response and make detection more difficult. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A91-20489
RECENT DEVELOPMENTS IN RAMJETS, DUCTED ROCKETS AND SCRAMJETS
Y. M. TIMNAT (Technion - Israel Institute of Technology, Haifa) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 27, no. 3, 1990, p. 201-235. refs
Copyright

An evaluation is made of powerplant configurations representative of the state-of-the-art in subsonic and supersonic combustion ramjets, as well as the combination of ramjet propulsion principles with rocket and turbomechanical features for hybrid cycles. Attention is given to the conceptual and practical development of combined rocket-booster/ramjet combustor chambers, and the evolution of configurational concepts for the integration of a scramjet propulsion apparatus into an HST lifting-body vehicle. Emphasis is given to the difficulties encountered in the design of regenerative cooling systems predicated on the use of LH2 fuel, as well as to the test facilities required for realistic scramjet operation. O.C.

A91-20612
SIMULATION AND STUDY OF SHEAR FLOWS SURROUNDING PROPFAN ENGINE MODELS [SIMULATION UND UNTERSUCHUNG DER SCHUBUMKEHRSTROEMUNGEN AN MODELLEN VON PROPFANTRIEBWERKEN]
DIETMAR CHRIST and REINHARD FRIEDRICHS (DLR, Hauptabteilung Windkanaele, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 24, 25. In German.
Copyright

The wind tunnels at Braunschweig and Goettingen have been used to investigate the shear flow around new kinds of propfan engines. The designs and performances of the shear flow simulations and engine models are briefly described. C.D.

A91-20737#
FLOWFIELD MEASUREMENTS IN AN UNSTABLE RAMJET BURNER
D. M. REUTER, U. G. HEGDE, and B. T. ZINN (Georgia Institute of Technology, Atlanta) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 680-685. Previously cited in issue 18, p. 3002, Accession no. A88-44678. refs
(Contract N00014-84-K-0470)
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A91-20744#
COMPARISON OF COMBUSTION EXPERIMENTS AND THEORY IN POLYETHYLENE SOLID FUEL RAMJETS
P. J. M. ELANDS, P. A. O. G. KORTING, T. WIJCHERS (TNO, Prins Maurits Laboratoria, Rijswijk, Netherlands), and F. DIJKSTRA (Delft, Technische Universiteit, Netherlands) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 732-739. Research supported by the Stichting voor de Technische Wetenschappen and National Fund for Supercomputers of Netherlands. Previously cited in issue 18, p. 3003, Accession no. A88-44738. refs
Copyright

A91-21205
TESTING AIR DATA SYSTEMS ON AIRCRAFT - PROBLEMS AND SOLUTIONS
G. R. WITT (Penny and Giles Avionic Systems, Ltd., Christchurch, England) IN: Maintenance of modern avionics systems; Proceedings of the Conference, Heathrow, England, May 9, 1989. London, Royal Aeronautical Society, 1989, p. 4.0-4.14.
Copyright

A major problem in testing air data and associated systems is that the testing should be noninvasive and in particular nondestructive. A review is presented of the operational problems encountered in carrying out maintenance within time and cost budgets. The approach presented leads to a maintenance capability that provides full testing under safe conditions with extended capability to meet increasing requirements. Examples are given of newly available test regimes utilizing this type of equipment that include off-aircraft testing, on-aircraft testing operational problems, and typical maintenance schedule requirements. A newly developed unit is described that consists of a calibrator/controller unit and a remote control display unit which are interconnected by a cable of up to 25 m in length. R.E.P.

A91-21222
OPTIMIZATION STUDIES FOR THE PW305 TURBOFAN
D. J. KARANJIA and R. A. HARVEY (Pratt and Whitney Canada, Longueil) ICAO Journal (ISSN 0018-8778), vol. 45, Aug. 1990, p. 9-12.
Copyright

A review is presented of the requirements, design, development and testing of the PW305 engine that will power the BAe 1000 business aircraft. The key design objectives included a maximum takeoff thrust of 23.24 kN, a mass of 431 kgs, a ten percent improvement in TSFC, and a fan diameter as close as possible to existing engines. Cycle studies were accomplished to optimize the total engine/airframe combination. The theoretical optimum for best specific fuel consumption had to be modified by considering physical size, mass, and cost. The paper focuses on the means by which the critical parameters were chosen for the basic cycle at the design condition of 12,000 m, Mach 0.8 at ISA and maximum cruise rating. Then the definition studies for compressor stages, high turbine choices, and specific thrust are described. Given the stated targets and constraints, the design bypass ratio chosen was 4.3, which for the target thrust requirement resulted in a fan diameter of 78.1 cm, or just over 2.5 cm larger than existing turbofans. R.E.P.

A91-21239
SIMULATION, TESTING AND OPTIMIZATION OF A NEW LOW COST ELECTRONIC FUEL CONTROL UNIT FOR SMALL GAS TURBINE ENGINES
G. CARRESE, T. KREPEC (Concordia University, Montreal, Canada), and C. H. TO (Bendix Avelex, Inc., Montreal, Canada) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 11 p. Research supported by NSERC and Bendix Avelex, Inc.
(SAE PAPER 901027) Copyright

The potential benefits of digital electronic controls, including increased flexibility and lower cost, have not yet been fully applied to the small gas turbine engines of remotely piloted vehicles. For these applications, the need for low cost is a strong factor in design. To address this situation, a new, simple and inexpensive electronically controlled metering system for small gas turbine engines is proposed. The system incorporates a diaphragm type valve keeping a constant differential pressure across a stepper motor actuated metering valve. To optimize the design, mathematical models were created for computer simulation. Experimental tests performed on a prototype showed that it can adequately meet the fuel schedules of small gas turbines. The simulation models were validated against the test results and were used in design optimization. Author

A91-21240
NUMERICAL SIMULATIONS OF AUXILIARY POWER UNITS WITH DIFFERENT CONFIGURATIONS
GIOVANNI TORELLA (Accademia Aeronautica, Naples, Italy) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 21 p. refs
(SAE PAPER 901028) Copyright

Development techniques are presented for the production of fast, flexible, and reliable numerical codes simulating auxiliary power units (APUs) of various configurations, with a view to the projection of both design-point and off-design condition performance characteristics. Attention is given to diagnostic and fault simulation functions, as well as to the transient behavior of APUs and the evaluation of control laws for satisfying specific constraints. Flowcharts are presented for engine simulation with a numerical code, the primary steps for calculations of influence matrices, and the steps of the iterative and component fault-simulation methods. O.C.

A91-21245
NEW FAMILY OF LOW COST ELECTRONIC FUEL CONTROL UNITS FOR SMALL GAS TURBINE ENGINES
T. KREPEC, A. I. GEORGANTAS (Concordia University, Montreal, Canada), M. TAYLOR, and C. H. TO (Bendix Avelex, Inc., Montreal, Canada) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 8 p. Research supported by NSERC and Bendix Avelex, Inc. refs
(SAE PAPER 901039) Copyright

A new family of low cost electronic fuel control units is being proposed for the small gas turbine engines of remotely piloted vehicles and auxiliary power units. A modular design incorporating an electronically actuated metering value is used which can be matched with various types of differential pressure valves controlling the pressure drop across the metering value. Four different configurations are proposed: metering valve only, metering value with diaphragm type differential pressure valve, metering valve with bypass valve and double valve configuration, and the latter with a back-up capability. Author

A91-21336*# Virginia Univ., Charlottesville.
COMBUSTION EFFICIENCY DETERMINED FROM WALL PRESSURE AND TEMPERATURE MEASUREMENT IN A MACH 2 COMBUSTOR
CORIN SEGAL, JAMES C. MCDANIEL, ROBERT B. WHITEHURST, and ROLAND H. KRAUSS (Virginia, University, Charlottesville) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract NAG1-795)
(AIAA PAPER 91-0017) Copyright

A study of transverse hydrogen injection behind a rearward facing step in a Mach 2 airflow was conducted to determine the combustion efficiency and the combustor/inlet interactions at the low temperature lean-mixture operational end of a scramjet combustor model. The fuel was injected at sonic conditions into the electrically heated airstream, which was maintained at 850 K or below. The static pressure delivered at the entrance of the combustor ranged between 0.25 to 0.5 atm. Injector configurations included single and staged injectors placed at 3 or 3-and-7 step-heights downstream of the step, respectively, with injector diameters of 1, 1.5, and 2 mm. Ignition was achieved by initially unstarting the test section. The constant area combustor and the low initial temperatures caused thermal choking and upstream interaction to occur at very low equivalence ratios. Typically, most of the fuel was burned in the recirculation region behind the step and around the jets. The effects of initial conditions (temperature and pressure), fuel-to-air dynamic pressure ratio, and boundaries (thermal vs adiabatic) are presented. Author

A91-21372#
AN ANALYTICAL STUDY OF A SUPERSONIC MIXER-EJECTOR EXHAUST SYSTEM
T. J. BARBER (United Technologies Research Center, East Hartford, CT) and O. L. ANDERSON AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0126) Copyright

A computational procedure has been developed for modeling the flowfield produced by a supersonic mixer-ejector exhaust system. The flowfield both within the mixing duct as well as in the downstream exhaust of the ejector has been modeled. The analytical procedure used in the present study is based on an efficient PNS analysis combined with empirical data obtained from previously presented analytical studies. The analytical studies reported here have been conducted for a flat plate shroud, flight-inlet mixer ejector operating at a nozzle exit Mach number of 1.5. Favorable comparisons with experimental data for both the static and near-static operating conditions have been made to demonstrate the validity of the analysis procedure. Comparison calculations are also presented for a slot nozzle ejector, having an equivalent nozzle exit area. The analytical results presented confirm the experimentally observed significant improvement in turbojet exhaust mixing available from recently developed mixer ejector concepts. In addition, the internal flow calculations provided insight into the interaction of the induced secondary flow with the outer shroud. Author

A91-21417#
PARAMETRIC STUDY ON THRUST PRODUCTION IN THE TWO DIMENSIONAL SCRAMJET
GARY A. ALLEN, JR. (Queensland, University, Brisbane, Australia) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0227) Copyright

The paper examines thrust production in the two-dimensional scramjet. The method of analysis used is the nonhomentropic

(nonisentropic) method of characteristics. This method is used in developing a computer program which takes a Mach number distribution as input and determines the thrust produced on the scramjet's diverging section. The Mach number distribution is found experimentally or through another numerical method. The resulting program is essentially a postprocessor which determines thrust for different scramjet geometries for a given Mach number distribution. In the paper some optimal angles for maximum pressure are described. Author

A91-21418#
HYPERSONIC PROPULSION SYSTEM FORCE ACCOUNTING
KEITH NUMBERS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(Contract F33615-87-C-3006)
(AIAA PAPER 91-0228)

A generic matrix of propulsion force accounting procedures has been developed from a survey of the aerospace community. The matrix includes definitions for propulsion system and control volume boundary specification. Aerodynamic reference conditions are also discussed relative to off-design performance. The advantages and disadvantages of each of the force accounting procedures are discussed as they apply to some typical hypersonic force accounting problems. Author

A91-21471#
ACTIVE CONTROL OF A DUMP COMBUSTOR WITH FUEL MODULATION
K. J. WILSON, E. GUTMARK, K. C. SCHADOW, and R. A. SMITH (U.S. Navy, Naval Weapons Center, China Lake, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0368)

Closed-loop control tests were performed to suppress the combustion instability of a dump combustor and to extend its flammability limits. The pressure oscillations originating from the unstable combustion were measured at the dump plane and at the exhaust nozzle. The signals were used as a reference to lock on and to produce an acoustic signal which modulated the fuel flow at a predetermined phase shift relative to them. At a certain range of phase shift angles the combustion oscillation amplitude was reduced to 50 percent of its unforced level. The control system was most effective when the reference signal was picked up at the dump. The amount of reduction was proportional to the acoustic forcing level, but leveled off for high forcing amplitudes. The effectiveness of the control system was reduced as the mass flow rate of the air was increased. The combustion instability became bimodal, with multiple unstable frequency and a more sophisticated lock-on, and a phase-shift system is required to suppress effectively oscillations with more than a single dominant frequency. However, even for the high flow rates the amplitude of the instability was reduced by nearly 40 percent. Author

A91-21475#
STRUCTURE OF A SUPERSONIC REACTING JET
R. S. BARLOW (Sandia National Laboratories, Livermore, CA), D. C. FOURGUETTE (Wellesley College, MA), M. G. MUNGAL (Stanford University, CA), and R. W. DIBBLE (California, University, Berkeley) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 24 p. Research supported by DOE. refs
(AIAA PAPER 91-0376)

An axisymmetric burner for the study of compressible reacting shear layers is described, and the ranges of its operating parameters are analyzed. This burner has a central supersonic free jet of resistively heated air, surrounded by a low-speed coflow of fuel-rich H2-air combustion products. Planar laser-induced fluorescence (PLIF) imaging of OH is used to visualize the structure of the annular reacting shear layer in the near field of the jet. Images from two cases with convective Mach numbers of 0.11 and 0.41 are presented and discussed in terms of previously reported results for nonreacting compressible shear layers. Results from a compressible 'lifted' flame are also presented and discussed in terms of the local Damkoehler number. The extension of these exploratory experiments to higher convective Mach numbers and higher Reynolds numbers is outlined. Author

A91-21482#
ACTIVE CONTROL OF COMBUSTION INSTABILITY IN A RAMJET USING LARGE-EDDY SIMULATIONS
SURESH MENON (Quest Integrated, Inc., Kent, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(Contract N00014-90-C-0089)
(AIAA PAPER 91-0411) Copyright

Combustion instability in a ramjet combustor has been numerically simulated using a large-eddy simulation (LES) technique. Premixed combustion in the combustor is simulated using a thin-flame model that explicitly uses the local turbulent flame speed in the governing equation. Two types of instability are observed: a small-amplitude, high-frequency instability and a large-amplitude, low-frequency instability. Both such instabilities have been experimentally observed, and various computed flow features are in good qualitative agreement with experimental observations. The information obtained from these simulations has been used to develop active control strategies to suppress the instabilities. Two active control techniques have been investigated: an acoustic feedback technique and secondary (both steady and unsteady) fuel injection. Control of both types of combustion instability was successfully achieved using the acoustic feedback technique, and the control could be used to turn the instability on and off. Secondary fuel injection also shows promise as an active control technique to suppress combustion instability. Author

A91-21483*# Massachusetts Inst. of Tech., Cambridge.
MULTI-DIMENSIONAL MODELLING OF GAS TURBINE COMBUSTION USING A FLAME SHEET MODEL IN KIVA II
W. K. CHENG (MIT, Cambridge, MA), M.-C. LAI (Wayne State University, Detroit, MI), and T.-H. CHUE AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. Research supported by Cummins Engine Co. refs
(Contract NAG3-1140)
(AIAA PAPER 91-0414) Copyright

A flame sheet model for heat release is incorporated into a multi-dimensional fluid mechanical simulation for gas turbine application. The model assumes that the chemical reaction takes place in thin sheets compared to the length scale of mixing, which is valid for the primary combustion zone in a gas turbine combustor. In this paper, the details of the model are described and computational results are discussed. Author

A91-21516#
TURBULENCE MODELING IN GAS TURBINE DESIGN AND ANALYSIS
O. P. SHARMA and S. A. SYED (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 22 p. refs
(AIAA PAPER 91-0514) Copyright

The current status of turbulence models, as applied to the design of components for aircraft gas turbine engines, is discussed. Aspects of turbomachinery flow fields are identified for which the unavailability of reliable turbulence models constrains design options. Areas of research are suggested where direct numerical simulations of Navier-Stokes equations can yield information leading to more reliable turbulence models; results from these simulations are also expected to provide improved insight into flow physics, benefitting design engineers. The relative importance of turbulence to periodic unsteadiness and boundary conditions is discussed. It is argued that parallel development in all three of these aspects of flow prediction is needed to harness the full potential of the recent explosive growth in computer storage, speed and Computational Fluid Dynamics (CFD) codes. Improved flow prediction capability should reduce both specific fuel consumption and the cost of development and ownership of gas turbine engines. Author

A91-21527#
FURTHER ASSESSMENT OF A SCRAMJET INLET MASS FLOW MEASUREMENT TECHNIQUE FOR USE IN HYPERSONIC PULSE FACILITIES
G. P. CORPENING, D. M. VAN WIE, and L. A. MATTES (Johns Hopkins University, Laurel, MD) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p.
(AIAA PAPER 91-0551) Copyright

The purpose of the study is to devise a mass-flow measurement technique for inlet tests in facilities with run times which are not sufficient to establish steady-flow conditions through a plenum/nozzle assembly. The equation relating plenum-pressure rate to mass capture is derived from the integral form of the energy equation. A mass-metering device for measuring inlet masss capture, consisting of a closed plenum with a striker plate and baffle arrangement to break up the imcoming flow and damp out internal flow oscillations is described. Test results obtained from a Ludwieg tube, gun tunnel, and Calspan shock tunnel are presented. Focus is placed on the quantitative assessment of the accuracy of the technique at a Mach-8 condition. It is shown that the accuracy of the meter is within 5 percent for the range from 1700 R to 3100 R. V.T.

A91-21575#
EXPERIMENTAL AND THEORETICAL STUDIES IN A GAS-FUELED RESEARCH COMBUSTOR
W. M. ROQUEMORE, V. K. REDDY (USAF, Aero Propulsion and Power Directorate, Wright-Patterson AFB, OH), P. O. HEDMAN (Brigham Young University, Provo, UT), M. E. POST, T. H. CHEN (Systems Research Laboratories, Inc., Dayton, OH) et al. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p. Research supported by USAF. refs
(AIAA PAPER 91-0639) Copyright

Results are presented from an experimental and theoretical investigation of the flow and flame behavior gas-fueled burner reproducing the recirculation patterns and 'lean blow-out' of an actual gas turbine combustor. As the equivalence ratio is reduced, the initially attached flame becomes less stable and eventually reaches a stage where the pilot flame lifts from the base region; the entire flame structure is then stabilized downstream. A CFD model with one-step chemistry is used to investigate the time-averaged features of the reacting and nonreacting flowfields. It is theorized that unburned hydrocarbon combustion products are transported into the recirculation zone by an intermittent process encountered in both attached and lifted flames. O.C.

A91-22879# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROGRESS IN HYPERSONIC COMBUSTION TECHNOLOGY WITH COMPUTATION AND EXPERIMENT
GRIFFIN Y. ANDERSON, AJAY KUMAR (NASA, Langley Research Center, Hampton, VA), and JOHN I. ERDOS (General Applied Science Laboratories, Ronkonkoma, NY) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 24 p. Research supported by the National Aero-Space Plane Joint Program Office. refs
(AIAA PAPER 90-5254) Copyright

Design of successful airbreathing engines for operation at near-orbital speeds presents significant challenges in all the disciplines involved, including propulsion. This paper presents a discussion of the important physics of hypersonic combustion and an assessment of the state of the art of ground simulations with pulse facilities and with computational techniques. Recent examples of experimental and computational simulations are presented and discussed. The need for continued application of these tools to establish the credibility and fidelity of engineering design methods for practical hypersonic combustors is emphasized along with the critical need for improved diagnostic methods for hypervelocity reacting flows. Author

A91-22885#
OPTIMIZATION AND VALIDATION OF A FUSELAGE FUEL TANK STRUCTURAL CONCEPT FOR THE NASP
FREDERICK T. MCQUILKIN and TRENT R. LOGAN (Rockwell International Corp., North American Aircraft Div., Los Angeles, CA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 11 p. refs
(AIAA PAPER 90-5262) Copyright

The success of the National Aerospace Plane in meeting its single-stage-to-orbit objective depends to a large degree on achieving an extremely low mass fraction. The major contributor to the dry weight of the vehicle is the airframe structure. Because of the use of hydrogen as fuel, with its low density and high poundage required, the fuselage fuel tank is the largest single element. Consequently, the optimization of this component of the vehicle will produce the maximum contribution to minimizing vehicle weight. The paper discusses the procedure which produced a circular, monocoque structure employing titanium aluminide truss-core sandwich with multi-layer insulation as the ideal tank/fuselage design. The validity of this approach was demonstrated by fabrication of full scale panels using the superplastic forming/diffusion bonding process as well as by structural testing. Author

A91-22892#
EXPERIMENTAL INVESTIGATION OF A 2-D DUAL MODE SCRAMJET WITH HYDROGEN FUEL AT MACH 4-6
V. A. VINOGRADOV, V. A. GRACHEV, M. D. PETROV, and IU. M. SHIKHMAN (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 11 p.
(AIAA PAPER 90-5269) Copyright

The paper presents the results of an experimental investigation of a working process in a model noncooled dual-mode scramjet with a two-dimensional inlet and combined combustor with hydrogen burning in subsonic and supersonic air flow. The investigation was conducted at freestream M = 5 and 6 and and also under conditions of connected duct, simulating the parameters at the combustor entry corresponding freestream M = 4. Distribution of gasthermodynamic parameters along the duct, efficiency of hydrogen-air mixture and combustion, special features of combustion stabilization, data on heat transfer and conditions of inlet and combustor interaction are discussed in this paper. Author

A91-23100#
AN APPLICATION OF AUTOMATIC IGNITOR DDK-1 TO TURBOJET ENGINE TEST UNDER SIMULATED ALTITUDE CONDITION
QIN ZHU (31st Research Institute, People's Republic of China) and XIAOHONG FAN (Design Institute of Aerospace, Chongqing, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Dec. 1990, p. 56-63. In Chinese, with abstract in English.

In this paper, an application of automatic ignitor DDK-1 in tests of a turbojet with an s-shape air inlet under simulated altitude condition are introduced. Automatic ignitor DDK-1 is useful for turbojet tests in simulated altitude conditions. Due to the use of automatic ignitor DDK-1, the process of engine test under high altitude simulation condition from igniting and starting to speeding up is completely automated. It is the first application of this ignitor to turbojet test under simulated altitude condition in China. Author

A91-23106#
A COMPUTATIONAL INVESTIGATION OF DUMP COMBUSTOR PERFORMANCE
CHING-HUA WANG (National Taiwan University, Taipei, Republic of China) and YI CHANG Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 11, Oct. 1990, p. 473-480. refs

A finite difference method with SIMPLE algorithm and power-law scheme is employed in this paper to compute two-dimensional axial symmetric dump (sudden expansion) combustor flow field and its performance. The combustion model is single one-step

chemical reaction model based on Arrhenius and eddy-breakup concept with scalar fluctuations for premixed situation. The k-epsilon turbulence model is used to close the Reynolds stress term. The computational results show some interesting effects of combustor parameters (configuration geometry, operating conditions, and fuel injection mode) on its performance (i.e., total pressure recovery and combustion efficiency), and provide engineers with useful informations for combustor design. Author

A91-23634#
ON THE LEADING EDGE - COMBINING MATURITY AND ADVANCED TECHNOLOGY ON THE F404 TURBOFAN ENGINE
S. F. POWEL (GE Aircraft Engines, Lynn, MA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 1-10.
(ASME PAPER 90-GT-149) Copyright

The overall design concept of the F404 afterburning turbofan engine is reviewed together with some of the lessons learned from over 2 million flight hours in service. GE Aircraft Engines' derivative and growth plans for the F404 family are then reviewed including the 'Building Block' component development approach. Examples of advanced technologies under development for introduction into new F404 derivative engine models are presented in the areas of materials, digital and fiber optic controls systems, and vectoring exhaust nozzles. The design concept and details of the F404-GE-402, F412-GE-400, and other derivative engines under full-scale development are described. Studies for future growth variants and the benefits of the F404 derivative approach to development of afterburning engines in the 18,000-24,000 lb thrust class and nonafterburning engines in the 12,000-19,000 lb class are discussed. Author

A91-23635#
ENGINE PERFORMANCE MONITORING AND TROUBLESHOOTING TECHNIQUES FOR THE CF-18 AIRCRAFT
R. W. CUE (Canadian Forces, Ottawa, Canada) and D. E. MUIR (GasTOPS, Ltd., Ottawa, Canada) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 11-19.
(ASME PAPER 90-GT-357) Copyright

The F404-GE-400 engines of the CF-18 aircraft are the first engines of the Canadian Forces to be maintained under a formal on-condition maintenance program. In support of this program, the Canadian Forces are developing advanced troubleshooting and performance monitoring procedures based on information recorded by the aircraft In-flight Engine Condition Monitoring System (IECMS). A suite of computer programs has been developed that enables maintenance personnel to access, display, and analyze in-flight event data recorded by the IECMS and to track the performance of individual engines based on 'health indices' derived from the IECMS takeoff ground roll recordings. The new techniques have been under evaluation at each of the CF-18 main operating bases for a period of approximately 14 months. Results to date indicate that the IECMS recordings provide a considerable amount of information of benefit to engine technicians and maintenance planners. Author

A91-23636#
SNECMA M88 ENGINE DEVELOPMENT STATUS
J. C. CORDE (SNECMA, Paris, France) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 20-24.
(ASME PAPER 90-GT-118) Copyright

The SNECMA M88-2 engine is a two-shaft, augmented mixed-flow turbofan intended for the Rafale next-generation fighter. An account is presently given of the design rationale for its configurations and the results of tests conducted to date on such major components as the low and high pressure compressors, the combustor, the high-pressure turbine, and the afterburner, as well as the engine's core components and the entire engine. Good general dynamic behavior and transitory response have been demonstrated, with excellent compressor stability and vibration behavior in all rotor blades and good thermal behavior of hot-section components. Both engine-mass and development-cost targets have been met. O.C.

A91-23637#
EJ200 - THE ENGINE FOR THE NEW EUROPEAN FIGHTER AIRCRAFT
J. R. LANE and J. BEHENNA (Rolls-Royce, PLC, Filton, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 25-32.
(ASME PAPER 90-GT-119) Copyright

The European Fighter Aircraft will be powered by two EJ200 engines of 20,000-lb thrust class designed to achieve the greatest possible compactness and lightness consistent with the need for a turbine entry temperature 200 C higher than current fighter engines, without compromising service life. The engine is of highly modular design, and has minimized turbomechanical structure weight and complexity through the use of low aspect ratio airfoils in both compressor and turbine blading. Each of the two spools operates with only a single turbine stage, and it is expected that carbon/carbon composites and ceramics will be employed in the hot section components as they become available. O.C.

A91-23638#
ADVANCED TECHNOLOGY PROGRAMS FOR SMALL TURBOSHAFT ENGINES - PAST, PRESENT, FUTURE
H. LINDSAY (GE Aircraft Engines, Lynn, MA) and E. T. JOHNSON ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 33-39. Research sponsored by the U.S. Army.
(ASME PAPER 90-GT-267) Copyright

A 15-year development history is presented for the U.S. Army Aviation Applied Technology Directorate's efforts to advance the state-of-the-art in small turboshaft engines, encompassing the 1500 shp GE12 technology demonstrator for the 1700 engine and the 5000 shp GE27 Modern Technology Demonstrator Engine. Attention is given to ongoing advanced technology component development programs and the performance goals thus far envisioned for the next generation of advanced gas generators applicable to turboshaft propulsion systems. Predictions are made for the propulsion system advancements required by the NASA/DOD Integrated High-Performance Turbine Engine Technology initiative through the year 2000. O.C.

A91-23642*# McDonnell Aircraft Co., Saint Louis, MO.
STOVL HOT GAS INGESTION CONTROL TECHNOLOGY
K. C. AMUEDO, B. R. WILLIAMS, J. D. FLOOD (McDonnell Aircraft Co., Saint Louis, MO), and A. L. JOHNS (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 68-74.
(ASME PAPER 89-GT-323) Copyright

A comprehensive wind tunnel test program was conducted to evaluate control of Hot Gas Ingestion (HGI) on a 9.2 percent scale model of the McDonnell Aircraft Company model 279-3C advanced Short Takeoff and Vertical Landing (STOVL) configuration. The test was conducted in the NASA-Lewis Research Center 9 ft by 15 ft Low Speed Wind Tunnel during the summer of 1987. Initial tests defined baseline HGI levels as determined by engine face temperature rise and temperature distortion. Subsequent testing was conducted to evaluate HGI control parametrically using Lift Improvement Devices (LIDs), forward nozzle splay angle, a combination of LIDs and forward nozzle splay angle, and main inlet blocking. The results from this test program demonstrate that HGI can be effectively controlled and that HGI is not a barrier to STOVL aircraft development. Author

A91-23645#
SIMULATION OF AIRCRAFT GAS TURBINE ENGINES
I. H. ISMAIL and F. S. BHINDER (Hatfield Polytechnic, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 95-99. refs
(ASME PAPER 90-GT-342) Copyright

The present FORTRAN 77 aircraft gas turbine simulation code was developed for IBM-compatible microcomputers and employs a high degree of modularity. Complete engine steady-state operation is modeled by means of either analytical equations or detailed performance characteristics of individual components. These components (air intake, compressor, combustor, turbine, and nozzle) can be variously assembled to represent different engine configurations, and will therefore be especially useful for exploratory, initial design-phase studies. O.C.

A91-23646#
DETERMINATION OF CYCLE CONFIGURATION OF GAS TURBINES AND AIRCRAFT ENGINES BY AN OPTIMIZATION PROCEDURE
Y. TSUJIKAWA and M. NAGAOKA (Osaka Prefecture, University, Sakai, Japan) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 100-105. refs
(ASME PAPER 90-GT-115) Copyright

This paper is devoted to the analyses and optimization of simple and sophisticated cycles, particularly for various gas turbine engines and aero-engines (including the scramjet engine) to achieve maximum performance. The optimization of such criteria as thermal efficiency, specific output, and total performance for gas turbine engines, and overall efficiency, nondimensional thrust, and specific impulse for aero-engines has been performed by the optimization procedure with the multiplier method. Comparison of results with analytical solutions establishes the validity of the optimization procedure. Author

A91-23647#
A NEW METHOD OF PREDICTING THE PERFORMANCE OF GAS TURBINE ENGINES
YONGHONG WANG (Shanghai Jiao Tong University, People's Republic of China) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 106-111.
(ASME PAPER 90-GT-337) Copyright

This paper points out that the turbine performance computation method used widely at present in solving the performance of gas turbine engines is a numerically unstable algorithm. Therefore a new method, namely an inverse algorithm, is proposed. This paper then further proposes a new mathematical model for solving the stable performance of gas turbine engines. It has the features of not only being suitable for an inverse algorithm for turbine performance, but also having fewer dimensions than existing models. It has the advantages of high accuracy, rapid convergence, good stability and fewer computations. It has been fully proven that the accuracy of the new model is much greater than that of the common model for gas turbine engines. Additionally, the time consumed for solving the new model is approximately 1/4 to about 1/10 of that for the common model. Author

A91-23648#
AN ALGORITHM AND CRITERIA FOR COMPRESSOR CHARACTERISTICS REAL TIME MODELING AND APPROXIMATION
A. M. EL-GAMMAL (Beograd, Univerzitet, Belgrade, Yugoslavia) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 112-118. Research sponsored by the Egyptian Air Force. refs
(ASME PAPER 90-GT-336) Copyright

Numerous problems are encountered in realizing an adequate real time model for an aircraft engine. The purpose of this article is to propose a systematic approach for modeling and approximating the characteristics of an engine or engine component parts, and to apply this approach to the Viper compressor (VC) characteristics. The proposed approach introduces a set of quantitative model-performance measures. Monitoring these measures makes it possible to take care of the multiple objectives of the model simultaneously and individually, and to attach a guarantee level to the model behavior. A set of (66) models are considered, from which the adequate VC model for real time (RT) simulation purposes is determined. Author

N91-15174*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OPTICAL MEASUREMENT OF UNDUCTED FAN FLUTTER
ANATOLE P. KURKOV and ORAL MEHMED 1990 11 p Prepared for presentation at the 36th International Gas Turbine and Aeroengine Congress and Exposition, Orlando, FL, 3-6 Jun. 1991; sponsored in part by the American Society of Mechanical Engineers
(NASA-TM-103285; E-5741; NAS 1.15:103285) Avail: NTIS HC/MF A03 CSCL 21/5

A nonintrusive optical method is described for flutter vibrations in unducted fan or propeller rotors and provides detailed spectral results for two flutter modes of a scaled unducted fan. The measurements were obtained in a high-speed wind tunnel. A single-rotor and a dual-rotor counterrotating configuration of the model were tested; however, only the forward rotor of the counterrotating configuration fluttered. Conventional strain gages were used to obtain flutter frequency; optical data provided complete phase results and an indication of the flutter mode shape through the ratio of the leading- to trailing-edge flutter amplitudes near the blade tip. In the transonic regime exhibited some features that are usually associated with nonlinear vibrations. Experimental mode shape and frequencies were compared with calculated values that included centrifugal effects. Author

N91-16020# Aeronautical Research Labs., Melbourne (Australia).
IFDIS: AN EXPERT SYSTEM FOR DIAGNOSIS OF FAILURES IN JET AIRCRAFT ENGINES
M. D. LARKIN (Deakin Univ., Australia), D. A. FRITH, and A. S. FINDLAY Jan. 1987 45 p
(AD-A227757; ARL-PROP-TM-439; DODA-AR-004-515) Avail: NTIS HC/MF A03

IFDIS (Interactive Fault Diagnosis and Isolation System) is being developed to aid in the F404 jet engines that are installed in the F/A-18 fighters. Existing documentation supporting troubleshooting for these engines is inflexible in the level of sophistication expected of the user and it does not explicitly use the reasoning with uncertain information which is inherent in human troubleshooting. Data, which is required for troubleshooting the F404, is currently or potentially available for computer processing from a number of sources. IFDIS will assist maintenance personnel by providing on-line access to relevant information and will perform much of the tedious interpretation of the available data. The expert knowledge embodied on some of the existing maintenance manuals has been re-expressed in a format that serves as the basis for the knowledge-base for an expert system. Expert systems techniques have been employed because they offer benefits of perspicuity, they can be developed incrementally and can cope with imprecise data. IFDIS is currently based on EMYCIN but will be reimplemented using a commercial expert system shell in the near future. Author

N91-16021*# General Motors Corp., Indianapolis, IN. Gas Turbine Div.
ADVANCED TURBINE TECHNOLOGY APPLICATIONS PROJECT (ATTAP) Final Annual Report, Jan. - Dec. 1989
2 Jul. 1990 137 p
(Contract DEN3-336; DE-AI01-85CE-50111)
(NASA-CR-187039; NAS 1.26:187039; EDR-14585; DOE/NASA/0336-2) Avail: NTIS HC/MF A07 CSCL 21/5

Advanced Turbine Technology Application Project (ATTAP) activities during the past year were highlighted by test-bed engine design and development activities; ceramic component design; materials and component characterization; ceramic component process development and fabrication; component rig testing; and test-bed engine fabrication and testing. Although substantial technical challenges remain, all areas exhibited progress. Test-bed engine design and development activity included engine mechanical design, power turbine flow-path design and mechanical layout,

and engine system integration aimed at upgrading the AGT-5 from a 1038 C metal engine to a durable 1371 C structural ceramic component test-bed engine. ATTAP-defined ceramic and associated ceramic/metal component design activities include: the ceramic combustor body, the ceramic gasifier turbine static structure, the ceramic gasifier turbine rotor, the ceramic/metal power turbine static structure, and the ceramic power turbine rotors. The materials and component characterization efforts included the testing and evaluation of several candidate ceramic materials and components being developed for use in the ATTAP. Ceramic component process development and fabrication activities are being conducted for the gasifier turbine rotor, gasifier turbine vanes, gasifier turbine scroll, extruded regenerator disks, and thermal insulation. Component rig testing activities include the development of the necessary test procedures and conduction of rig testing of the ceramic components and assemblies. Four-hundred hours of hot gasifier rig test time were accumulated with turbine inlet temperatures exceeding 1204 C at 100 percent design gasifier speed. A total of 348.6 test hours were achieved on a single ceramic rotor without failure and a second ceramic rotor was retired in engine-ready condition at 364.9 test hours. Test-bed engine fabrication, testing, and development supported improvements in ceramic component technology that will permit the achievement of program performance and durability goals. The designated durability engine accumulated 359.3 hour of test time, 226.9 of which were on the General Motors gas turbine durability schedule. Author

N91-16022# Karlsruhe Univ. (Germany, F.R.). Fakultaet fuer Maschinenbau.
EXPERIMENTAL AND THEORETICAL EXAMINATIONS OF FILM COOLING OF GAS TURBINE BLADES Ph.D. Thesis [EXPERIMENTELLE UND THEORETISCHE UNTERSUCHUNGEN ZUR FILMKUEHLUNG VON GASTURBINENSCHAUFELN]
WOLFGANG HAAS 1989 245 p In GERMAN
(ETN-91-98554) Avail: NTIS HC/MF A11

Film cooling measurements are carried out in a grid channel with relatively low velocities to obtain data for the development and the safeguarding of calculation models. The influence of the density ratio, the Reynolds number and the turbulence degree on the cooling efficiency, and the heat transfer number was investigated. The formation and the development of velocity and temperature profiles were also investigated in the case of a plane blade grid. A calculation process based on a numerical solution of the stationary two dimensional conservation equations for mass, impulse, and energy in the boundary shape was developed which characterizes the velocity and temperature fields at turbine blades. ESA

N91-16023# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
JET ENGINE PERFORMANCE ESTIMATION FROM MINIMAL INPUT DATA M.S. Thesis
MARK PITT 27 Nov. 1990 234 p
(ETN-91-98582) Copyright Avail: NTIS HC/MF A11

From a photograph of a subject aircraft for which drag characteristics can be estimated, determination of an engine cycle which matches the engine thrust to the aircraft drag characteristics is attempted. A database collating the facets of engine design important to the analysis task is established. Computer routines are used to assist in the analysis. The expected output of the assessment methodology is defined. The performance of the method is critically examined to determine its strengths and weaknesses. The assessment was found to be highly sensitive to the values of total pressure at the engine inlet and as calulated at the nozzle exit. ESA

N91-16024# Loughborough Univ. of Technology (England). Dept. of Electrical and Electronic Engineering.
AN INTRODUCTION TO MODERN AERO-ENGINE CONTROL DESIGN M.S. Thesis
B. A. MOORE 27 Nov. 1990 104 p
(ETN-91-98583) Copyright Avail: NTIS HC/MF A06

The fundamental requirements of aeroengine controllers are discussed. Using the example of a remotely piloted vehicle engine controller, a simple in service system is analyzed from the control engineer view. The relationship between theory and practice is discussed. The fundamental concepts underlying a unique research control system for a military gas turbine power plant are examined. The complexity of the technique needed for safe and efficient control of a modern jet engine is briefly discussed. The idea of employing multivariate techniques in a modern aeroengine controller is considered. A simple engine controller design exercise based on a military aeroengine is undertaken, using a modern control compensator design technique. ESA

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A91-20610
DISCUS - A FAILURE-TOLERANT FBW/FBL-EXPERIMENTAL SYSTEM [DISCUS - EIN FEHLERTOLERANTES FBW/FBL-EXPERIMENTALSYSTEM]
GUENTER MANSFELD, KLAUS BENDER, and KLAUS-DIETER HOLLE (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 6-11. In German.
Copyright

The DISCUS (Digital Self-healing Control for Upgraded Safety) system for helicopters is discussed. DISCUS offers one-fail-op capability, flexible hardware structure, modular construction capability, high performance due to multiprocessor capability, and adaptability to higher computer languages. The DISCUS computer architecture and its fly-by-wire/fly-by-night system are examined. The DISCUS yaw control concept and flight measurement technology are described. C.D.

A91-20991
FLIGHT-TEST-DERIVED STABILITY DERIVATIVES FOR THE ADVANCED TECHNOLOGY TACTICAL TRANSPORT
ROBERT G. HOEY IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 3.4-1 to 3.4-10.
Copyright

A 62 percent scale Advanced Technology Tactical Transport (ATTT) proof of concept vehicle was constructed and flight tested under a contract to DARPA. This aircraft was a twin turboprop, tandem wing design with large flaps incorporated on both lifting surfaces for STOL performance, and it was constructed with all-composite materials. In support of the flight test program, a simple parameter identification scheme was developed for a personal computer based on the analog matching concept. Relatively simple, linear, perturbation response models (two degrees of freedom in pitch, three degrees of freedom in roll/yaw) were programmed on the PC and used to identify primary stability and control derivatives from flight test maneuvers of the scale ATTT. The lateral-directional response model was also utilized to establish preliminary gain requirements for a yaw damper in the power approach configuration. R.E.P.

A91-20992
ESTIMATION OF AERODYNAMIC AND MODE PARAMETERS OF AIRCRAFT'S OPEN AND CLOSED-LOOP SYSTEM
CHANG-YE QUAN (China Flight Test Research Centre, Xian, People's Republic of China) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989,

Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 3.5-1 to 3.5-8. refs
Copyright

This paper describes flight test techniques for estimating aerodynamic derivatives and mode parameters of aircraft with automatic flight control systems. These techniques include ground test, control input, data acquisition systems, and the method for processing flight testing data, the maximum likelihood algorithm. Mathematical models used in parameter estimation are given. They include longitudinal airframe and equivalent airframe models. The estimation results of airframe and equivalent airframe aerodynamic derivatives and mode parameters for eleven maneuvers are also given and a brief analysis is done. The test results show that the short-period mode characteristics of aircraft with automatic flight control systems are improved and that it is possible to use equivalent airframe models to estimate equivalent aerodynamic derivatives and mode parameters of aircraft with automatic flight control systems. Author

A91-21004
AM-X HIGH INCIDENCE TRIALS, DEVELOPMENT AND RESULTS
B. MARCHETTO and G. MENSO (Aeritalia S.p.A., Turin, Italy) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 6.7-1 to 6.7-10. Previously announced in STAR as N90-26016.
Copyright

The activities carried out to investigate the high angle of attack/spin characteristics of the AM-X are described. Vertical wind tunnel and rotary balance facilities were used to collect all the information on aircraft behavior at stall, beyond stall, and in developed spin required to efficiently approach the flight test activity. A special training of the ground monitoring team and adequate use of the telemetry facilities allowed the efficient employment of flight time. Analysis of the test results allowed validation and identification of the aerodynamics model. Flight controls modifications useful to improve the aircraft behavior at high incidence are suggested. Author

A91-21230
AN ANALYSIS OF THE SU-27 FLIGHT DEMONSTRATION AT THE 1989 PARIS AIR SHOW
ANDREW M. SKOW (Eidetics International, Inc., Torrance, CA) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 15 p.
(SAE PAPER 901001) Copyright

From an initial position of 1000 ft above ground level and 220 knots indicated airspeed, Viktor Pougachev flew an Su-27 fighter at the 1989 Paris Air Show into a rapid nose-up maneuver which reached a peak pitch attitude of 110-120 deg. Attention is presently given to: (1) the potential tactical value of this 'cobra' maneuver; (2) the possibility that other aircraft in Western air forces may be able to duplicate the maneuver; and (3) the design characteristics that are required for an advanced fighter aircraft to perform this maneuver. Simulation experiments have been conducted with all U.S. fighters; only the F-16 has been able to demonstrate sufficient nose-up pitch-control power for the cobra maneuver, but weak lateral-directional stability and pitch-down control power will preclude successful duplication. O.C.

A91-21231
AIR-TO-GROUND ATTACK FIGHTER IMPROVEMENTS THROUGH MULTI-FUNCTION NOZZLES
PAUL W. HERRICK (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 11 p. refs
(SAE PAPER 901002) Copyright

The benefits of pitch/yaw thrust vectoring and/or thrust reversing multi-function nozzles (MFN) for fighter type aircraft have been identified relative to the air-to-air mission in several previous papers. This paper will point out those previously noted payoffs which also apply to air-to-ground attack fighters. It will also present a detailed description of air-to-ground unique multi-function nozzle benefits. Specific treatment will be given to close air support, battlefield interdiction, suppression of enemy air defenses, and deep strike missions. MFN contributions to air-to-ground survivability and effectiveness will be emphasized relative to the critical aspects of basing, ingress, target attack, self defense, egress and recovery. Actual air-to-ground attack historical data will be employed as it is applicable to this discussion. Author

A91-21232
RELATIONSHIPS BETWEEN AGILITY METRICS AND FLYING QUALITIES
DAVID R. RILEY and MARK H. DRAJESKE (McDonnell Aircraft Co., Saint Louis, MO) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 14 p. refs
(SAE PAPER 901003) Copyright

Various agility measures of merit, called metrics, have been proposed to define and measure aircraft agility. The proposed agility metrics are intended to offer designers new insight into aircraft maneuverability and controllability. This paper discusses the relationships between these new agility metrics and traditional flying qualities parameters for the lateral and longitudinal axes. In general, traditional flying qualities parameters are found to be a significant part of describing an aircraft's agility. Flying qualities considerations also help to explain trends in agility metrics that are otherwise unexplainable. Author

A91-21233
MEASURES OF MERIT FOR AIRCRAFT DYNAMIC MANEUVERING
JURI KALVISTE (Northrop Corp., Aircraft Div., Hawthorne, CA) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 13 p.
(SAE PAPER 901005) Copyright

New parameters which characterize aircraft dynamic maneuvering performance in air-to-air combat have been developed. The parameters are functions of both the time to perform the task and the spatial aspects of the maneuver. They have been developed for a point-and-shoot engagement and roll reversal maneuver, although the procedure is sufficiently general that it can be applied to most combat maneuvers. The parameters can be used to predict the outcome of air-to-air engagements and the time advantage that one aircraft has against another aircraft. Author

A91-21249
VERIFICATION OF FLIGHT CRITICAL SYSTEMS
EMRAY GOOSSEN (Honeywell, Inc., Defense Avionics Systems Div., Albuquerque, NM) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 9 p.
(SAE PAPER 901051) Copyright

Increasingly widespread use of ever-more-complex fly-by-wire aircraft controls exacerbates the safety-assurance problems faced by flight control system designers, which are already severe due to the compromising of system testing by flight scheduling pressures. Attention is presently given to a concept which promises to improve costs, scheduling, and safety in future fly-by-wire system development; the heart of the concept is a fully-automated integration, verification, and validation (IVV) capability. A proof-of-concept automated IVV demonstration conducted as part of the X-31 program has yielded results which are presently given. O.C.

A91-22201#
FLIGHT MANAGEMENT/GUIDANCE SYSTEM IN AIR TRANSPORT USING AIRBUS A320 AS AN EXAMPLE [DAS FLIGHT MANAGEMENT/GUIDANCE SYSTEM IN DER LUFTFAHRT AM BEISPIEL DES AIRBUS A320]
H. NEUMANN (Deutsche Lufthansa AG, Cologne, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 3, 1990, p. 316-324. In German and English.

The Flight Management/Guidance system of the Airbus 320 is

outlined and graphically illustrated. Comparisons are made with standard systems in aircraft navigation systems. The development of the Airbus 320 system is briefly reviewed. C.D.

A91-22251#
CONTROL LAW STUDY OF AIRCRAFT MANEUVERS AT HIGH ATTACK ANGLE
XIONG HE and HAO GAO (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B411-B419. In Chinese, with abstract in English. refs

Based on bifurcation analysis and catastrophe theory, a novel theoretical method for forecasting jump bifurcation phenomena in control space is established. By studying singular lines in the bifurcation surfaces, critical values of control surfaces for avoiding rapid-roll divergence and extending the rapid-roll maneuver scope are obtained. The control law for bringing aircraft into stall and spin and returning them to stable and controllable states at low angles of attack is worked out. Author

A91-22265#
AIR-TO-GROUND ATTACK AND INTEGRATED FLIGHT/FIRE CONTROL
LEJIN HUANG and LINCHANG ZHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B503-B506. In Chinese, with abstract in English. refs

It is demonstrated that the air-to-ground attack plays an important role in war. Taking the air-to-ground attack as the application background, the paper shows the effect of Integrated Flight/Fire Control (IFFC) on enhancement of the mission efficiency of military aircraft. The evolution, technical foundation, and development trend of IFFC are summarized. Finally, some suggestions on the development of IFFC in China are given. Author

A91-22352#
A CALCULATING METHOD OF THE KILL PROBABILITY ATTACK AREA FOR AAM
TINGJIE LI, RUNQUAN LIU, CHAOZHI WANG (Beijing University of Aeronautics and Astronautics, People's Republic of China), GUXIANG ZHU, and LIZHEN WANG (Ministry of Aeronautics and Astronautics, 014 Center, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, July 1990, p. A315-A322. In Chinese, with abstract in English.

This paper provides a calculating method which can be used in calculation of the kill-probability attack area for every air-to-air missile (AAM). First, the attack area of the AAM and the kill probability of every characteristic point are obtained by combining trajectory and kill-probability calculations. Then the coordinates of a fire point relative to the standard kill probability value are found in terms of a standardization method. Equivalent kill probability curve equations are then formulated by means of a curve-fitting method. Author

A91-22371#
PREDICTIVE CONTROL OF OPTIMAL PATH TERRAIN FOLLOWING SYSTEM
SHUNDA XIAO (Northwestern Polytechnical University, Xian, People's Republic of China) and BENGANG CHEN (Leihua Electronic Technology Research Institute of China, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B343-B347. In Chinese, with abstract in English. refs

An output prediction algorithm is applied to the design of a predictive controller for an optimal path terrain-following system. The tracking error of the path is thereby simply and efficiently reduced to a small degree, and the computing time for the optimal path is also greatly reduced. All of this makes the real-time processing of the optimal path terrain-following system look promising. S.A.V.

A91-22950*# Sverdrup Technology, Inc., Cleveland, OH.
INTEGRATED FLIGHT/PROPULSION CONTROL SYSTEM DESIGN BASED ON A CENTRALIZED APPROACH
SANJAY GARG, DUANE L. MATTERN (Sverdrup Technology, Inc., Cleveland, OH), and RANDY E. BULLARD (NASA, Lewis Research Center, Cleveland, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 107-116. Previously cited in issue 23, p. 3620, Accession no. A89-52611. refs
Copyright

A91-22959#
NEW TECHNIQUE FOR AIRCRAFT FLIGHT CONTROL RECONFIGURATION
MARCELLO R. NAPOLITANO and ROBERT L. SWAIM (Oklahoma State University, Stillwater) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 184-190. Previously cited in issue 23, p. 3616, Accession no. A89-52527. refs
Copyright

A91-22961*# California Univ., Davis.
TECHNIQUE FOR PREDICTING LONGITUDINAL PILOT-INDUCED OSCILLATIONS
R. A. HESS (California, University, Davis) and R. M. KALTEIS Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 198-204. Previously cited in issue 23, p. 3620, Accession no. A89-52609. refs
(Contract NCC2-490)
Copyright

A91-22962*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
NATIONAL AEROSPACE PLANE LONGITUDINAL LONG-PERIOD DYNAMICS
DONALD T. BERRY (NASA, Flight Research Center, Edwards, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 205, 206. Previously cited in issue 21, p. 3495, Accession no. A88-50601.
Copyright

A91-23641#
INTEGRATED PROPULSION SYSTEM REQUIREMENTS FOR CONTROL OF STOVL AIRCRAFT
G. W. GALLOPS, C. F. WEISS, and R. A. CARLTON (Pratt and Whitney Group, West Palm Beach, FL) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 113, Jan. 1991, p. 60-67. refs
(ASME PAPER 90-GT-364) Copyright

This paper describes an evaluation of propulsion system requirements and capability for a Short Take-Off/Vertical Landing (STOVL) aircraft employing modulation of the propulsive lift distribution for pitch and roll control in hover. The effects of propulsive lift nozzle configuration and propulsion system dynamic response were evaluated using a combined system simulation consisting of a six degree of freedom aircraft model, engine model, and integrated flight/propulsion control. The response and stability of propulsive lift control are compared with control by reaction jets supplied by engine bleed. Aircraft performance is demonstrated in simulated STOVL maneuvers using a dynamic pilot model. The conclusion of this study is that propulsive lift control of aircraft pitch and roll is feasible and can provide as much as a 10 percent increase in engine lift rating over systems that employ reaction control alone. The dynamic response of practical propulsive lift configurations, however, is less than that of reaction control configurations, which must be offset through integration of the propulsion system and its control. Author

A91-23743#
INTEGRATED AEROELASTIC CONTROL OPTIMIZATION
T. N. DRACOPOULOS and H. OZ (Ohio State University, Columbus) IN: Dynamics and control of large structures;

Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 361-378. refs

A new design methodology is developed and demonstrated for the aeroelastic control of composite lifting surfaces. This design is formulated as an optimization problem in connection with determining the laminate design and the control law which maximizes the critical aeroelastic (flutter or divergence) speed of an actively controlled composite lifting surface without excessive expenditure of control energy. The integrated aeroelastic control optimization methodology is formulated and illustrated for composite lifting surfaces simulated by rectangular symmetric cantilevered composite plates with structural and control constraints. The formulation includes the Rayleigh-Ritz energy method, a two-dimensional incompressible unsteady aerodynamic theory, parameter optimization, and optimum control design techniques. This design gave results that exhibited 102 percent higher critical aeroelastic speed with 294.4 percent lower control cost compared to designs obtained by a nonintegrated design procedure. R.E.P.

A91-24113
AUTOMATIC FLIGHT CONTROL SYSTEMS
DONALD MCLEAN (Southampton, University, England) Englewood Cliffs, NJ, Prentice Hall, 1990, 606 p. refs
Copyright

The present introductory work on automatic flight control systems proceeds from a brief development history for this technology to the equations of motion for an aircraft within the stability axis system and for steady maneuvering flight, the nature of the most important stability derivatives, and such aspects of aircraft stability and dynamics as the phugoid and lateral motion transfer functions and the two- and three-degree-of-freedom approximations. Attention is also given to the dynamic effects of structural flexibility on aircraft motion, disturbances affecting aircraft motion, flying and handling qualities, control system design methods, stability-augmentation systems, helicopter flight controls, and adaptive flight control systems. O.C.

N91-15175 Maryland Univ., College Park.
HIGHER HARMONIC CONTROL ANALYSIS FOR VIBRATION REDUCTION OF HELICOPTER ROTOR SYSTEMS Ph.D. Thesis
KHANH QUOC NGUYEN 1989 258 p
Avail: Univ. Microfilms Order No. DA9021560

An advanced higher harmonic control (HHC) analysis was developed and applied to investigate its effect on vibration reduction levels, blade and control system fatigue loads, rotor performance, and power requirements of servo-actuators. The analysis is based on a finite element method in space and time. A nonlinear time domain unsteady aerodynamic model, based on the indicial response formulation, is used to calculate the airloads. The rotor induced inflow is computed during a free wake model. The vehicle trim controls and blade steady responses are solved as one coupled solution using a modified Newton method. A linear frequency-domain quasi-steady transfer matrix is used to relate the harmonics of the vibratory hub loads to the harmonics of the HHC inputs. Optimal HHC is calculated from the minimization of the vibratory hub loads expressed in terms of a quadratic performance index. Predicted vibratory hub shears are correlated with wind tunnel data. Due to the applied HHC, the blade torsional stresses and control loads are increased substantially. For flight conditions where the blades are stalled considerably, the HHC input-output model is quite non-linear. The fixed-gain controller performs poorly for such flight conditions. It was determined that a soft-inplane hingeless rotor requires less actuator power at high speeds than an articulated rotor, and a stiff-inplane hingeless rotor generally requires more actuator power than an articulated or a soft-inplane hingeless rotor. Parametric studies for a hingeless rotor operating in a transition flight regime and for an articulated rotor operating at the level-flight boundary indicate that blade parameters including flap, lag, torsion stiffness distributions, linear pretwist, chordwise offset of center-of-mass from elastic axis, and chordwise offset of elastic axis from aerodynamic center all have some influences on the actuator power requirements. Dissert. Abstr.

N91-15176 Maryland Univ., College Park.
DAMPING ESTIMATION IN HELICOPTER ROTOR STABILITY TESTING Ph.D. Thesis
FREDERICK ABAYOMI TASKER 1990 162 p
Avail: Univ. Microfilms Order No. DA9031001

Estimating the damping of helicopter rotor blade modes is complicated by rotor harmonics, high measurement noise, close modes, and the difficulty of exciting modes in the rotating environment. Methods are developed and evaluated for obtaining improved estimates of modal damping from rotor stability test data. Two transient analysis methods, Moving-Block analysis and the Sparse Time Domain (STD) method are studied. Two refinements in Moving-Block analysis are introduced: High resolution recursive spectral analysis and a recursive frequency domain interpretation for the Hanning window to reduce leakage from close modes. Singular Value Decomposition is applied to the STD method and a procedure to calculate only the structural modes from the system matrix is developed. The techniques are evaluated for noisy data, close damped and undamped modes, for low and high damping levels. Subspace methods substantially improve the time domain estimation for noisy data, but require higher computation time. A method is developed that retains the low variance estimation property of the subspace methods, but is comparable in computation cost to baseline methods. Its performance is evaluated for multi-output and single out-put implementations and compared to the standard STD method. Equivalent Damping is estimated using modified versions of the Moving-Block analysis technique and the STD method from numerical simulations. Effects of rotor harmonics and noise on the performance of these techniques are evaluated. Dissert. Abstr.

N91-15177# Naval Postgraduate School, Monterey, CA. Dept. of Aeronautics and Astronautics.
APPLICATION OF CHAOS METHODS TO HELICOPTER VIBRATION REDUCTION USING HIGHER HARMONIC CONTROL Ph.D. Thesis
MARTINUS M. SARIGUL-KLIJN Mar. 1990 202 p
(AD-A226736) Avail: NTIS HC/MF A10 CSCL 01/1

Chaos is used to understand complex nonlinear dynamics. The geometric and topological methods of Chaos theory are applied, for the first time, to the study of flight test data. Data analyzed is from the OH-6A Higher Harmonic Control (HHC) test aircraft. HHC is an active control system used to suppress helicopter vibrations. Some of the first practical applications of Chaos methods are demonstrated with the HHC data. Although helicopter vibrations are mostly periodic, evidence of chaos was found. The presence of a strange attractor was shown by computing a positive Lyapunov exponent and computing a non integer fractal correlation dimension. A broad band Fourier spectrum and a well defined attractor in pseudo phase space are observed. A limit exists to HHC vibration reduction due to the presence of chaos. A new technique based on a relationship between the Chaos methods (the Poincare section and Van der Pol plane) and the vibration amplitude and phase was discovered. This newly introduced technique results in the following: (1) it gives the limits of HHC vibration reduction; (2) it allows rapid determination of best phase for a HHC controller; (3) it determines the minimum HHC controller requirement for any helicopter from a few minutes duration of flight test data; and (4) it shows that the HHC controller transfer matrix is linear and repeatable when the vibrations are defined in the Rotor Time Domain and that the matrix is nonlinear and nonrepeatable when the vibrations are defined. GRA

N91-15178# Aeronautical Research Labs., Melbourne (Australia).
FLIGHT FLUTTER TEST TECHNIQUES AT ARL Aircraft Structures Technical Memorandum
P. A. FARRELL and T. G. RYALL Aug. 1990 26 p

(AD-A227754; ARL-STRUC-TM-569; DODA-AR-006-121) Avail: NTIS HC/MF A03 CSCL 01/1

Good design of an aircraft ensures that its flutter speed lies beyond its maximum operating speed; however, modification of the aircraft, such as the attachment of external stores to the wings, can lower the flutter speed significantly. In this case it may be necessary to determine experimentally the new flutter speed by means of a series of flight flutter trials. During such trails the aircraft is excited in flight and the measured response analysed to obtain estimates of the structural natural frequencies and damping ratios. Some of the methods are described which were used in Australia to excite aircraft in flight flutter trials, together with the analytical techniques used to reduce the resulting data. Typical results from trials are presented. GRA

N91-15179# Sandia National Labs., Albuquerque, NM. Aircraft Compatibility Div.

AIRCRAFT COMPATIBILITY TASKS REQUIRED FOR THE RELEASE OF AN AIRCRAFT COMPATIBILITY CONTROL DRAWING (ACCD)

GARTH L. MAXAM Nov. 1990 17 p

(Contract DE-AC04-76DP-00789)

(DE91-004698; SAND-90-2373) Avail: NTIS HC/MF A03

The Aircraft Compatibility Division at Sandia National Laboratories has the responsibility to assure that the aircraft that have been designed to carry and release nuclear gravity bombs are indeed compatible with the bombs. Division personnel work with Air Force and Navy personnel and their contractors to make sure that bomb electrical, mechanical, and aerodynamic requirements are fully understood. Once an aircraft has been designed, a series of tests and analyses are run on the aircraft/bomb nuclear weapon system and descriptive weapon system documentation is produced. At the conclusion of an aircraft compatibility program, a recommendation is made to add the aircraft to the nuclear gravity bomb Aircraft Compatibility Control Drawing (ACCD). DOE

N91-15180*# Boeing Aerospace Co., Seattle, WA.

INTEGRATED CONTROL-STRUCTURE DESIGN Final Report

K. SCOTT HUNZIKER, RAYMOND H. KRAFT, and JOSEPH A. BOSSI 15 Jan. 1991 65 p

(Contract NAS1-18762)

(NASA-CR-182020; NAS 1.26:182020) Avail: NTIS HC/MF A04 CSCL 01/3

A new approach for the design and control of flexible space structures is described. The approach integrates the structure and controller design processes thereby providing extra opportunities for avoiding some of the disastrous effects of control-structures interaction and for discovering new, unexpected avenues of future structural design. A control formulation based on Boyd's implementation of Youla parameterization is employed. Control design parameters are coupled with structural design variables to produce a set of integrated-design variables which are selected through optimization-based methodology. A performance index reflecting spacecraft mission goals and constraints is formulated and optimized with respect to the integrated design variables. Initial studies have been concerned with achieving mission requirements with a lighter, more flexible space structure. Details of the formulation of the integrated-design approach are presented and results are given from a study involving the integrated redesign of a flexible geostationary platform. Author

N91-15181# Sheffield Univ. (England). Dept. of Control Engineering.

A REAL-TIME DISTRIBUTED OPTIMAL AUTOPILOT

G. S. VIRK and J. M. TAHIR Jun. 1990 13 p

(RR-398; ETN-91-98526) Avail: NTIS HC/MF A03

A new distributed optimal autopilot for aircraft flight control is presented. A parallel processing approach is taken where the longitudinal and lateral motions with cross coupling effects are handled in different processors. The proposed control algorithm is implemented on a T800 transputer network programmed using parallel C, and it is shown that real time performance is possible. ESA

N91-15182*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

INITIAL FLIGHT TEST OF A GROUND DEPLOYED SYSTEM FOR FLYING QUALITIES ASSESSMENT

MARY F. SHAFER, RUTHARD KOEHLER, EDWARD M. WILSON, and DAVID R. LEVY (Air Force Systems Command, Andrews AFB, MD.) Aug. 1989 10 p Presented at the AIAA Atmospheric Flight Mechanics Conference, Boston, MA, 14-16 Aug. 1989

(NASA-TM-101700; H-1554; NAS 1.15:101700; AIAA-89-3359)

Avail: NTIS HC/MF A02 CSCL 01/3

In order to provide a safe, repeatable, precise, high-gain flying qualities task a ground deployed system was developed and tested at the NASA Ames Research Center's Dryden Flight Research Facility. This system, the adaptable target lighting array system (ATLAS), is based on the German Aerospace Research Establishment's ground attack test equipment (GRATE). These systems provide a flying-qualities task, emulating the ground-attack task with ground deployed lighted targets. These targets light in an unpredictable sequence and the pilot has to aim the aircraft at whichever target is lighted. Two flight-test programs were used to assess the suitability of ATLAS. The first program used the United States Air Force (USAF) NT-33A variability stability aircraft to establish that ATLAS provided a task suitable for use in flying qualities research. A head-up display (HUD) tracking task was used for comparison. The second program used the X-29A forward-swept wing aircraft to demonstrate that the ATLAS task was suitable for assessing the flying qualities of a specific experimental aircraft. In this program, the ground-attack task was used for comparison. All pilots who used ATLAS found it be highly satisfactory and thought it to be superior to the other tasks used in flying qualities evaluations. It was recommended that ATLAS become a standard for flying qualities evaluations. Author

N91-15183# Massachusetts Inst. of Tech., Cambridge. Technology Lab. for Advanced Composites.

NONLINEAR LARGE AMPLITUDE VIBRATION OF COMPOSITE HELICOPTER ROTOR BLADE AT LARGE STATIC DEFLECTION Interim Technical Report

TAEHYOUN KIM and JOHN DUGUNDJI 25 Jul. 1990 91 p

(Contract DAAL03-87-K-0024)

(AD-A227933; TELAC-90-14; ARO-24023.4-EG) Avail: NTIS HC/MF A05 CSCL 01/3

The nonlinear, large amplitude free vibration of composite helicopter blades under large static deflection is investigated analytically. A new model capable of handling large amplitudes as well as large deflections was developed, based on the work in a previous report by Minguet. The model can deal with large displacements and rotations by use of Euler angles and can account for structural couplings such as bending-twist and extension-twist. The reduction of this large deflection model to a commonly used moderate deflection model is also shown. A Newton-Raphson type iterative solution technique based on numerical integration of the basic large deflection equations is seen effective for the present analysis. It is found that both large static deflection and large amplitudes can affect the fore-and-aft and torsion modes significantly, but bending modes are not influenced much by the geometrical nonlinearities. GRA

N91-16025 Purdue Univ., West Lafayette, IN.

AEROSERVOELASTIC TAILORING FOR LATERAL CONTROL ENHANCEMENT Ph.D. Thesis

CHANGHO NAM 1990 166 p

Avail: Univ. Microfilms Order No. DA9031368

A fundamental study of aeroservoelastic tailoring for roll control is presented. The effects of combining the structural tailoring of the lifting surface (ply orientation and thickness), together with the wing geometry (sweep angle and taper ratio), and the control surface geometry (spanwise position and chordwise size of the control surface) upon the lateral control effectiveness are discussed. Several optimization examples for the minimization of

control surface hinge moment, subject to constant roll effectiveness, are performed. To understand the effects of aeroservoelastic tailoring, two different levels of approach are used. First, a simple beam model is used to represent a high aspect ratio flexible wing. Second, a plate model is used for the more accurate structural analysis. The ELAPS code, the general equivalent plate analysis program, is used for the structural analysis. The best spanwise location of the control surface for flutter suppression is found, by using Nissim's aerodynamic energy concept. The results are compared with those of the best spanwise position of the control surface for roll control. The formulation for optimization studies when the wing weight is included as a part of the objective function is presented. Optimization examples for the simultaneous minimization of wing and control surface hinge moment are considered. Results show that the control surface hinge moment can be minimized by reorienting the ply angle and redesigning the wing, control surface geometry. Even the hinge moment and wing weight can be minimized simultaneously.
Dissert. Abstr.

N91-16026# Loughborough Univ. of Technology (England). Dept. of Electrical and Electronic Engineering.
LONGITUDINAL STABILITY AUGMENTATION OF A LIGHTWEIGHT FIGHTER AIRCRAFT MODEL M.S. Thesis
W. A. FERNIE 1989 161 p
(ETN-91-98585) Copyright Avail: NTIS HC/MF A08

Two control systems are assessed and tested over a range of incidence values, in order to evaluate the effectiveness of the designs. A suitable aircraft model is developed and aerodynamic data for the F16 fighter aircraft are used to ensure that the resulting longitudinal behavior of the model is unsatisfactory. The stability criteria are established and the existing defense standard criteria for the short period oscillation are selected. Both control systems produce better results when the designs are based on the fourth order model. The performance of a digital compensator is studied. The quantization and discretization errors are evaluated. An optimum sampling rate is selected. The effects of system delays on aircraft handling qualities are considered. ESA

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A91-20613
PROFILE MEASUREMENTS IN TRANSONIC WIND TUNNEL BRAUNSCHWEIG [PROFILMESSUNGEN IM TRANSSONISCHEN WINDKANAL BRAUNSCHWEIG]
WOLFGANG PUFFERT-MEISSNER (DLR, Hauptabteilung Windkanaele, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 26-28. In German.
Copyright

The Braunschweig wind tunnel and its operation are briefly discussed. The instruments used in the tunnel are mentioned. The Mach number and Reynolds number of the tunnel are graphically depicted. C.D.

A91-20978
THE RADIO TRIALS CENTRE AT A&AEE BOSCOMBE DOWN, UNITED KINGDOM - A DESCRIPTION
JOHN HOWES (Aeroplane and Armament Experimental Establishment, Navigation and Radio Div., Boscombe Down, England) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 1A.3-1 to 1A.3-10.
Copyright

The paper presents a review of the activities conducted by the Radio Trials Centre, which provides RF measurement facilities for the airborne testing of aircraft communications, radar, radio navigation, electronic warfare and other RF link-based systems. Among the principal capabilities provided by the center are network analysis facilities, mobile measurement facilities, and an acoustic noise laboratory. These capabilities and the range of tests which they support are discussed. R.E.P.

A91-20983
COST CONSCIOUS DESIGN FOR DATA ACQUISITION SYSTEM GROUND SUPPORT EQUIPMENT
JAMES B. MCCORMICK (McDonnell Aircraft Co., Saint Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2A.3-1 to 2A.3-6.
Copyright

Inexpensive and powerful desktop computer systems and improvement in software programming methods have permitted the development of support equipment at an order-of-magnitude cost reduction, while supporting much more complex systems. This paper describes the McDonnell Douglas Digital Data Acquisition System Ground Support Equipment, which combines MS/DOS based computer systems and C programming language software routines. The routines have been modularized into three functional areas: a flight preparation program, a flight line unit program, and a preflight data assessment program. Program details are provided for the interfaces, flight preparation, multiple format capability, preflight assessment and verification, real-time display and the format quality check progam. R.E.P.

A91-20984
A MEASUREMENT SYSTEM FOR PRODUCTION FLIGHT TESTS OF NEW AIRCRAFT
R. VAN DE LEIJGRAAF, W. A. VAN DORP., S. STROM VAN LEEUWEN, and R. UDO (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 2A.4-1 to 2A.4-9. refs
Copyright

A measurement system has been developed for the production flight tests of the Fokker 50 and the Fokker 100 production aircraft. This system includes a data acquisition module that gathers data from the aircraft systems and records this raw data on magnetic tape for backup, and a data processing module that performs the calibration of the measured data, and the real-time calculation of performance parameters. Then quick-look presentation facilities during the measurements of the production flight tests are provided. The measurement system for the production flight tests is described, with emphasis on the software and hardware of the data processing module. R.E.P.

A91-21179
GROUND FACILITIES FOR HYPERSONIC SIMULATION
A. WATSON and A. J. WAKE (British Aerospace /Military Aircraft/, Ltd., Preston, England) IN: International Conference on Hypersonic Aerodynamics, Manchester, England, Sept. 4-6, 1989, Proceedings. London, Royal Aeronautical Society, 1989, p. 3.1-3.13. refs
Copyright

A hypersonic blowdown tunnel that is both affordable and within the current state-of-the-art, is proposed along with one or more hypervelocity shock tunnels of the free-piston type. These would make a major contribution to the development and validation of advanced computer codes, and increase confidence in the ability to minimize vehicle weight by reducing design margins. This paper discusses the urgent need for advanced hypersonic ground test facilities for the European aerospace community and the options available for acquiring them. It is shown that the range of tests and parameters required can be considerably extended by introducing the hypersonic and hypervelocity regimes. In addition to the normal measurements of loads, values of stagnation temperature, moments and pressures, heat transfer and wall

temperature ratios are required. These and other requirements serve to illustrate the severe demands placed on the ground test facilities. R.E.P.

A91-21200
AIRPORT TECHNOLOGY INTERNATIONAL 1990/1991
MAURICE G. HUDSON, ED. London, Sterling Publishing Group, PLC, 1990, 276 p. No individual items are abstracted in this volume.
Copyright

This review of civil aviation, airport, and airline ground management considers international policies and legislation, airport policy management, the planning, design and construction of airports, and airport commercial operations. Also presented are papers covering a systems approach to airport security, ramp operation and handling, airfield operations, and air traffic control and navigation. R.E.P.

A91-22172
SOVIET ATC RESEARCH
OLIVER SUTTON Aerospace World (ISSN 0983-1592), vol. 4, Dec. 1990, p. 37, 38.
Copyright

A review of the Soviet International Air Traffic Control Research Center and its activities are presented. A seminatural modeling facility (SETA) is designed for real-time research of ATC operations with the participation of a human operator in the simulation modeling area. The SETA complex makes it possible to simulate processes of planning and air traffic control by taking into account peculiarities of control zones and individual areas. The system is capable of following up to 100 targets simultaneously and processing as many as 400 flight plans. Utilizing datalink, the experiments have shown that a controller can easily manage up to 30 aircraft at the same time, with less stress than when using today's conventional system. A program is also being undertaken to build up a flow management databank, designed to be compatible with Eurocontrol's new central databank. R.E.P.

A91-22307
AIRCRAFT PLATFORM SCALES WITHOUT SIDELOAD INDUCED WEIGHING ERRORS
EARL STUDLIEN (Electro-Services, Inc., Hudson, MA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 8 p.
(SAWE PAPER 1882) Copyright

Initial tests of the weighing platforms built for the B-1B program revealed sideload errors which were in due course eliminated through (1) a redesign of the load-beam mounting so that it 'floats', and (2) the application of the load to the knife-edges of a yoke resting on the concave section of the load beam. The outer frame of the platform was also designed to achieve enough flexibility for conformance to irregularities in the hangar floor or ramp. The experience gained in this highly challenging program was then applied to the design of two versions of the weighing platform for general aviation use; these are the Portable Aircraft Digital Scale and the Portable Aircraft Weighing System. O.C.

A91-22308
A STATE OF THE ART MASS PROPERTIES LABORATORY
GEORGE W. TULEY and JOSE GARCIA (McDonnell Douglas Helicopter Co., Mesa, AZ) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 27 p. refs
(SAWE PAPER 1883) Copyright

The 'Mass Properties Laboratory' (MPL) developed by a major helicopter manufacturer accomplished weight and center-of-gravity measurements, static balancing of helicopter main rotor blades, inertia measurements, and the dynamic balancing of main rotor hubs and tail rotors. These functions are accomplished with accuracy, repeatability, linearity, and easy maintainability and calibration. The MPL's dynamic balancing capability derives from the incorporation of a hard-bearing vertical balancing apparatus; all other components are substantially simpler and require no computer interface. All prospective rotorcraft designs currently envisioned can be accommodated by the MPL. O.C.

A91-22863#
STRUCTURAL TESTS FOR THE DORNIER 328
EBERHARD JOHST and PETER WAIBEL Dornier Post (ISSN 0012-5563), no. 4, 1990, p. 39-42.
Copyright

The design of the Dornier 328 airliner, which makes extensive use of fiber composites and must meet the JAR and FAR rules for a damage-tolerant design of aircraft structures, is presented. The airliner has a 3.5-m pressurized cabin section for 30 passengers, and a specified service life of 65,000 flights. The share of the fiber composites in the airframe structure is about 25 percent. Fiber composites are also used in the rear pressure bulkhead. Unidirectional CFRP prepregs form the rear fuselage and tail unit. The development and qualification test program includes static and dynamic airframe tests as well as tests on bird strike, CFRP components, components critical for air stability, and the pressurized fuselage section. The tests are planned to be conducted in 1991/93, and a full-scale ground vibration test is a prerequisite for take-off clearance. B.P.

N91-15185# Air Force Engineering and Services Center, Tyndall AFB, FL. Environics Div.
A CONTROLLED-ENVIRONMENT CHAMBER FOR ATMOSPHERIC CHEMISTRY STUDIES USING FT-IR SPECTROSCOPY Final Report, Jan. 1986 - Jun. 1988
DANIEL A. STONE Jun. 1990 57 p
(Contract AF PROJ. 0100)
(AD-A227532; AFESC/ESL-TR-89-44) Avail: NTIS HC/MF A04
CSCL 07/4

A one meter diameter, Teflon coated, stainless steel sphere was constructed as a tool for conducting studies of the atmospheric chemistry of toxic chemicals. The temperature can be controlled from 5 to 50 C. The chamber can be evacuated to 5 X 10(exp -6) torr. Gas samples can be introduced from an external manifold. Solid samples of various kinds can be placed into the interior of the chamber through a 12 in sampling port to determine their effects on gases under study. The chamber is equipped with an in situ, multipass optical system which allows infrared path lengths of 100 meters to be used for the analysis of chemical species. GRA

N91-15186# Oak Ridge National Lab., TN.
RADIOLUMINESCENT (RL) AIRFIELD LIGHTING SYSTEM PROGRAM Annual Report, 1 Oct. 1986 - 30 Sep. 1987
J. A. TOMPKINS (Westinghouse Electric Corp., Las Vegas, NV.), K. W. HAFF, and F. J. SCHULTZ Sep. 1990 74 p
(Contract DE-AC05-84OR-21400)
(DE91-001007; ORNL/TM-11503) Avail: NTIS HC/MF A04

In 1980, the U.S. Air Force Engineering and Services Center (AFESC) at Tyndall Air Force Base, Florida, requested that the Radioisotope Technology Group of Oak Ridge National Laboratory (ORNL) develop large-scale, tritium-powered, radioluminescent (RL) airfield lighting systems. The RL lighting systems possess the advantages of being portable, requiring no electrical power source, having a long shelf life, and being unaffected by environmental extremes. These characteristics make the RL system well-suited for harsh environments where the cost of electrical power production is high and traditional incandescent airfield lighting systems are difficult to maintain. RL lighting is typically a large-surface-area, low-intensity light source that operates 100 percent of the time. The RL light sources gradually decrease in brightness over time, so periodic replacement (every 6 to 8 years) is necessary. RL lighting functions best in low ambient light, which provides the high contrast ratios necessary for successful use of these devices. DOE

N91-15188*# Cryolab, Inc., San Luis Obispo, CA.
COST-EFFECTIVE USE OF LIQUID NITROGEN IN CRYOGENIC WIND TUNNELS, PHASE 2 Final Report, Jul. 1987 - Dec. 1990
GLEN E. MCINTOSH, DAVID S. LOMBARD, KENNETH R.

LEONARD, and GERALD D. MORHORST Dec. 1990 71 p (Contract NAS1-18481)
(NASA-CR-182088; NAS 1.26:182088; D6-44238-5) Avail: NTIS HC/MF A04 CSCL 14/2

Cryogenic seal tests were performed and Rulon A was selected for the subject nutating positive displacement expander. A four-chamber expander was designed and fabricated. A nitrogen reliquefier flow system was also designed and constructed for testing the cold expander. Initial tests were unsatisfactory because of high internal friction attributed to nutating Rulon inlet and outlet valve plates. Replacement of the nutating valves with cam-actuated poppet valves improved performance. However, no net nitrogen reliquefaction was achieved due to high internal friction. Computer software was developed for accurate calculation of nitrogen reliquefaction from a system such as that proposed. These calculations indicated that practical reliquefaction rates of 15 to 19 percent could be obtained. Due to mechanical problems, the nutating expander did not demonstrate its feasibility nor that of the system. It was concluded that redesign and testing of a smaller nutating expander was required to prove concept feasibility.
Author

N91-15189# Federal Aviation Administration, Atlantic City, NJ.
EFFECTS OF RUNWAY ANTI-ICING CHEMICALS ON TRACTION
RICK MARINELLI Nov. 1990 68 p
(DOT/FAA/CT-TN90/53) Avail: NTIS HC/MF A04

This study was conducted to determine the effects of runway anti-icing chemicals on traction. Chemicals were applied to cold runway surfaces, and water was added in increments to simulate freezing rain. Friction coefficients were measured throughout with a Saab Friction Tester. The results of the study show that pavements in otherwise good condition will not experience an unsafe drop in friction levels when anti-icing chemicals are applied at the manufacturers' recommended rates, but that pavements with poor microtexture may become slippery. Author

N91-16031# Army Engineer Waterways Experiment Station, Vicksburg, MS. Geotechnical Lab.
EVALUATION PROCEDURE FOR REINFORCED CONCRETE BOX CULVERTS UNDER AIRFIELD PAVEMENTS Final Report, Jan. 1983 - Mar. 1990
DAVID M. COLEMAN, JAMES A. HARRISON, and STANLEY C. WOODSON Sep. 1990 81 p Sponsored by Corps of Engineers, Washington, DC and AFESC, Tyndall AFB, FL
(AD-A227920; WES/TR/GL-90-25) Avail: NTIS HC/MF A05 CSCL 12/5

While most airfield pavements are periodically evaluated to determine their structural capacity, often little thought is given to the structural capacity of the culverts and other drainage structures beneath the pavement. The Department of Defense has never had a standard means of evaluating box culverts under airfields or landing strips. This capacity has been needed on several occasions, particularly overseas where landing strips are sometimes built into the local highway system. The research reported herein evaluated several different methods for performing the structural evaluation of reinforced concrete box culverts under aircraft loads, selected two computer programs (CANDE-1980 and CORTCUL) for detailed testing, and then developed a culvert evaluation methodology based on the CORTCUL program. To assist in determining the aircraft loads, an additional computer program was developed. This program, CULVERT, uses elastic layer theory and predefined aircraft data to calculate the vertical stress acting on the top of the culvert due to the aircraft and also provides output and plotting capabilities. Stress is then applied to the culvert model along with the member loads, soil loads, and other loads such as internal water. The CORTCUL program evaluates the culvert based on the requirements of ACI 318, Building Code Requirements for Reinforced Concrete. GRA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A91-20618
CONCEPT AND SPECIFICATION FOR THE HERMES TRAINING AIRCRAFT (HTA) [KONZEPT UND SPEZIFIKATION FUER DAS HERMES TRAINING AIRCRAFT /HTA/]
DIETRICH HANKE (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 48-52. In German.
Copyright

The training concept and technical specification for the development of the Hermes Training Aircraft are discussed. The aircraft modification involved in that development and the resulting model systems are described. Various systems are diagrammed.
C.D.

A91-20743#
FLOW MEASUREMENTS IN A MODEL RAMJET SECONDARY COMBUSTION CHAMBER
LAZAR T. CHITTILAPILLY (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India), S. VENKATESWARAN, P. J. PAUL, and H. S. MUKUNDA (Indian Institute of Science, Bangalore, India) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 727-731. Research supported by the Defence Research and Development Laboratory of India. refs
Copyright

Experimental studies were conducted on a typical secondary combustion chamber of a ramjet to understand the influence of various inlet parameters such as primary nozzle configuration, secondary air injection angle, and flow Reynolds numbers on the secondary combustion chamber (SCC) performance. Cold flow studies were made with air as the flow medium for both primary and secondary jets followed by similar studies with hot primary jets. The general flow structure in the SCC obtained from surface oil film technique showed recirculation zones near the head end. The combustor length required for jet mixing was found to be unrelated to recirculation zone length confirmed by selective temperature and total pressure profile measurements. The calculated frictional loss from the momentum balance consideration was found to be small. That significant improvement in mixing can be achieved by a choice of multiple-hole primary nozzle configuration has been demonstrated. Author

A91-22877*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE AEROSPACE PLANE DESIGN CHALLENGE - CREDIBLE COMPUTATIONAL FLUID DYNAMICS RESULTS
UNMEEL B. MEHTA (NASA, Ames Research Center, Moffett Field, CA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 17 p. refs
(AIAA PAPER 90-5248) Copyright

In order to establish the credibility of CFD results utilized in aerospace plane design, the following topics are discussed: CFD validation in relation to 'measureable' fluid dynamics (MFD) validation, credibility requirements, responsibility for credibility, and a guide for establishing credibility. What is of paramount concern for fluid dynamic design is not CFD code validation but qualification of CFD unknowns so that their magnitude is greatly reduced and that these uncertainties are employed for designing with margin. The designers must be trained to properly use CFD if they are to produce good designs. In approximately 70 percent of the flight envelopes of SSTO aerospace planes with supersonic combustion,

CFD will be necessary to determine dynamics performance and specifications. R.E.P.

A91-22888*#
MANNED VERSUS UNMANNED - THE IMPLICATIONS TO NASP
THEODORE WIERZBANOWSKI and TERRY D. KASTEN (National Aero-Space Plane Joint Program Office, Wright-Patterson AFB, OH) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 12 p. refs
(AIAA PAPER 90-5265)

The assessment of unmanned approaches to experimental aerospace vehicles in general and to the NASP program in particular is summarized. Technical requirements for NASP demonstration are presented and unmanned options for satisfying requirements are discussed. The X-30 sensitivities to technical requirements are described. A correlation of the NASP program to prior flight test programs, both manned and unmanned, is also presented. It is noted that subscale vehicles may reduce risk by as much as 18 percent for approximately $200 M. It is concluded that half-scale vehicles may reduce program risk by 60 percent, while reducing X-30 costs by 40 percent. Also, an unmanned X-30 will probably cost more than a manned X-30 due to costs associated with additional software development and ground support systems costs. L.K.S.

A91-22889#
AEROSPACE SYSTEM DEVELOPMENT DIRECTIONS AND SOME ASPECTS OF THEIR CONSTRUCTION AND APPLICATION
G. I. ZAGAINOV, V. P. PLOKHIKH, L. M. SHKADOV, and V. A. IAROSHEVSKII (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 17 p.
(AIAA PAPER 90-5266) Copyright

International cooperation in aerospace system development is discussed, focusing on the costs to be shared and benefits to be gained by joint, rather than independent, development. Some current activities of the Soviet aerospace program are outlined, mentioning Energiia-Buran system development and the Mria program. The concept of applying the carrier Mria as the first stage for the injection of a two-stage vehicle into the launch trajectory is also discussed. It is argued that international cooperation on various projects which would mutually benefit all peoples, such as the timely detecting asteroids and the prevention of their collision with the earth, is not only advisable, but necessary. L.K.S.

A91-22960*# California Univ., Davis.
CLOSED-LOOP ASSESSMENT OF FLIGHT SIMULATOR FIDELITY
RONALD A. HESS (California, University, Davis) and TERRY MALSBURY Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 191-197. Research supported by the U.S. Army. Previously cited in issue 09, p. 1393, Accession no. A89-25010. refs
(Contract NAG2-482)
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N91-15295# Computer Technology Associates, Inc., McKee City, NJ.
AERONAUTICAL MOBILE SATELLITE SERVICE (AMSS) CAPACITY ANALYSIS AND PROTOCOL PERFORMANCE SIMULATION PLAN
THOMAS DEHEL Oct. 1990 16 p
(Contract DTFA03-89-C-00023)
(DOT/FAA/CT-TN90/35) Avail: NTIS HC/MF A03

This plan describes the simulation and analysis which will be performed on the Aeronautical Mobile Satellite Service (AMSS) communication system. Two system aspects which are examined in this effort are AMSS capacity and message transit delay. The capacity results are generated by software written as a part of this effort; the message transit delay results are generated by a simulation program called ADSSIM written by Boeing and provided to the Federal Aviation Administration (FAA). The analysis of the results will include a comparison to project system requirements. Author

N91-15303*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE AERODYNAMIC CHARACTERISTICS OF VORTEX INGESTION FOR THE F/A-18 INLET DUCT
BERNHARD H. ANDERSON Jan. 1991 40 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored in part by AIAA
(NASA-TM-103703; E-5925; NAS 1.15:103703; AIAA-91-0130)
Avail: NTIS HC/MF A03 CSCL 01/3

A Reduced Navier-Stokes (RNS) solution technique was successfully combined with the concept of partitioned geometry and mesh generation to form a very efficient 3D RNS code aimed at the analysis-design engineering environment. Partitioned geometry and mesh generation is a pre-processor to augment existing geometry and grid generation programs which allows the solver to (1) recluster an existing gridlife mesh lattice, and (2) perturb an existing gridfile definition to alter the cross-sectional shape and inlet duct centerline distribution without returning to the external geometry and grid generator. The present results provide a quantitative validation of the initial value space marching 3D RNS procedure and demonstrates accurate predictions of the engine face flow field, with a separation present in the inlet duct as well as when vortex generators are installed to supress flow separation. The present results also demonstrate the ability of the 3D RNS procedure to analyze the flow physics associated with vortex ingestion in general geometry ducts such as the F/A-18 inlet. At the conditions investigated, these interactions are basically inviscid like, i.e., the dominant aerodynamic characteristics have their origin in inviscid flow theory. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A91-20677
METALLURGICAL CONTROL OF FATIGUE CRACK PROPAGATION IN SUPERALLOYS
K.-M. CHANG, M. F. HENRY, and M. G. BENZ (GE Physical Metallurgy Laboratory, Schenectady, NY) JOM (ISSN 1047-4838), vol. 42, Dec. 1990, p. 29-35. refs
Copyright

Low-cycle fatigue life of turbine engine disk alloys is determined by the initiation and propagation of fatigue cracks. Performance improvements can be achieved through the combination of clean melting technology, to reduce the defect size, and a new generation of high-strength superalloys with fatigue-cracking resistance. Metallurgical control of fatigue crack propagation in high-strength superalloys becomes feasible only through a clear understanding of the fatigue-cracking mechanism, as well as the microstructure/property relationships. Many metallurgical parameters have been identified to control the fatigue cracking resistance at high temperatures. One of the most effective methods, applicable to all high gamma-prime content superalloys, is to modify the grain boundary structure by means of a controlled cooling from a supersolvus solutioning. The precipitation reaction occurring on the grain boundaries during cooling generates a serrated structure that exhibits a good stress oxidation resistance for fatigue cracking. Author

A91-20776
ASSESSMENT OF IMPACT DAMAGE IN TOUGHENED RESIN COMPOSITES
C. POON, T. BENAK, and R. GOULD (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 13, May 1990, p. 81-97. refs
Copyright
An evaluation of impact performance of three commercial toughened resin systems against the baseline T300/5208 material is studied, using an instrumented dropweight impact method. It is shown that the toughened resin systems can absorb a much higher level of elastic energy than the baseline system. The baseline system absorbs inelastic energy by fiber and matrix fractures that coalesce to form a major through-the-thickness crack with extensive delaminations in every ply of the laminate. Toughened resin systems have better resistance to impact loading as evidenced by the production of barely visible impact damage (BVID) in contrast to the production of easily visible impact damage in the baseline system for the same impact energy. It is also shown that the residual compressive properties for the toughened resin systems are higher than those for the baseline system. Y.P.Q.

A91-20864
PROPERTIES OF ADVANCED RAPIDLY SOLIDIFIED TITANIUM ALLOYS
R. A. AMATO, G. E. WASIELEWSKI (GE Aircraft Engines, Cincinnati, OH), M. F. X. GIGLIOTTI, and R. G. ROWE (GE Corporate Research and Development Center, Schenectady, NY) IN: Advances in powder metallurgy; Proceedings of the 1989 Powder Metallurgy Conference and Exhibition, San Diego, CA, June 11-14, 1989. Volume 3. Princeton, NJ, Metal Powder Industries Federation, 1989, p. 189-201. refs
(Contract F33615-83-C-5034)
Copyright
The tensile and creep properties of a range of rapidly solidified titanium alloys were surveyed. Detailed evaluation of two compositions included tensile, creep, fatigue crack growth, and oxidation tests. Property improvements equivalent to a 140 C advantage in tensile strength and an advantage in creep resistance over Ti-6242S were observed. Author

A91-20879
TITANIUM COMPRESSOR EGGSHELLS
GERALD FRIEDMAN (Precision Castparts Corp., Cleveland, OH) IN: Advances in powder metallurgy; Proceedings of the 1989 Powder Metallurgy Conference and Exhibition, San Diego, CA, June 11-14, 1989. Volume 3. Princeton, NJ, Metal Powder Industries Federation, 1989, p. 401-411. refs
Copyright
The use of metal-cored wax patterns, atomized titanium alloy powder, precision canisters, and HIP consolidation, has made it possible to produce high strength, ductile, thin-wall hollow structures for both static and dynamic applications in the compressor section of aircraft gas turbine engines. The commercial manufacture of this type of component is possible because of the fortuitous combination of a number of critical factors including the availability of high-purity titanium alloy powder, the development and reduction to practice of an all-metal powder-consolidation technology, and (most importantly) the present need for hollow compressor components which are sufficiently strong and tough to constitute an acceptable risk when they are employed in the 'front end' of the engine. The dimensional, metallurgical, and mechanical property attributes of these 'titanium eggshells' are discussed. Author

A91-20881
THE PRODUCTION OF PREP TITANIUM POWDER
P. R. ROBERTS (Nuclear Metals, Inc., Concord, MA) IN: Advances in powder metallurgy; Proceedings of the 1989 Powder Metallurgy Conference and Exhibition, San Diego, CA, June 11-14, 1989. Volume 3. Princeton, NJ, Metal Powder Industries Federation, 1989, p. 427-438. refs
Copyright
One of the applications for the plasma rotating electrode process (PREP), which was developed originally for producing high-quality Ti PM for aerospace applications, includes manufacture of coarse spherical particles that can be used in the formation of porous structures on the stems of prosthetic devices to enhance their mechanical attachment by ingrowth of bone tissue. This paper describes a modified version of PREP, where molten particles are immersed in liquid argon, showing that the particle size distribution is refined over that obtained in original PREP procedure. I.S.

A91-21226
ADDITIONAL FUEL COMPONENT APPLICATION FOR HYDROGEN SCRAMJET BOOSTING
A. S. RUDAKOV and V. V. KRIUCHENKO (Tsentral'nyi Nauchno-Issledovatel'skii Institut Aviatsionnogo Motorostroeniia, Moscow, USSR) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 9 p. refs
(SAE PAPER 900990) Copyright
The results of computational investigations carried out to clarify the possibilities of hydrogen scramjet thrust uprating in hypersonic flight by adding to the fuel various substances of higher density are presented. Thrust, specific impulse, and density impulses are calculated, while adding nitrogen, oxygen, water or inert liquefied gases. For scramjet boosting in hypersonic flight it is suggested that the oxygen or a heavy inert gas be added to stoichiometric part of hydrogen, instead of the excessive part of hydrogen.
Author

A91-21473*# Old Dominion Univ., Norfolk, VA.
RADIATIVE INTERACTIONS IN A HYDROGEN-FUELED SUPERSONIC COMBUSTOR
R. CHANDRASEKHAR, S. N. TIWARI (Old Dominion University, Norfolk, VA), and J. P. DRUMMOND (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NAG1-363; NAG1-423)
(AIAA PAPER 91-0373) Copyright
The two-dimensional, elliptic Navier-Stokes equations are used to investigate supersonic flows with finite-rate chemistry and radiation, for hydrogen-air systems. The chemistry source term in the species equation is treated implicitly to alleviate the stiffness associated with fast reactions. The explicit, unsplit MacCormack finite-difference scheme is used to advance the governing equations in time, until convergence is achieved. The specific problem considered is the premixed flow in a channel with a 10-deg compression ramp. Three different chemistry models are used, accounting for increasing number of reactions and participating species. Two chemistry models assume nitrogen as inert, while the third model accounts for nitrogen reactions and NO(x) formation. The tangent slab approximation is used in the radiative flux formulation. A pseudogray model is used to represent the absorption-emission characteristics of the participating species. Results otained for specific conditions indicate that the radiative interactions vary substantially, depending on reactions involving HO2 and NO species, and that this can have a significant influence on the flowfield. Author

A91-21962
EFFECT OF THE PENETRATION DEPTH OF FUEL JETS ON COMBUSTION IN A SUPERSONIC COMBUSTION CHAMBER [VLIIANIE GLUBINY PRONIKNOVENIIA TOPLIVNYKH STRUI NA GORENIE V SVERKHZVUKOVOI KAMERE SGORANIIA]
S. I. BARANOVSKII and I. V. KONOVALOV Fizika Goreniia i Vzryva (ISSN 0430-6228), vol. 26, July-Aug. 1990, p. 66-68. In Russian.
Copyright
Experiments were carried out to investigate the effect of the relative penetration depth of hydrogen gas jets injected into supersonic cross-stream on self-ignition and combustion in a combustion chamber of constant cross section. The water-cooled experimental apparatus had a test section of 100x50 mm and a

Mach 2.5 supersonic nozzle. It is found that the combustion efficiency of multiple-jet supersonic combustion chambers is largely determined by the ratio of the penetration depth to the boundary layer thickness at the point of injection. V.L.

A91-22109
COMPOSITE MATERIALS IN AIRCRAFT STRUCTURES
DONALD H. MIDDLETON, ED. Harlow, England/New York, Longman Scientific and Technical/John Wiley and Sons, Inc., 1990, 406 p. No individual items are abstracted in this volume.
Copyright

The present work discusses the development history of composite materials in aircraft applications, composite structures' thus-far demonstrated capabilities and adaptability, types of aerospace composite matrices and reinforcing fibers, the relationship of fiber-matrix interfaces to resulting composite strengths, micromechanics and the failure properties of composites, and design rules and techniques for composites. Also discussed are load-carrying composite joints, advanced composite tooling and manufacturing methods, composite NDE and quality assurance, and composite repair methods. Case histories are presented for the incorporation of composite structures by the Airbus airliners, the Harrier AV-8B, the C-130 airlifter, high-performance gliders, propellers, radomes, and carbon-carbon aircraft brakes. O.C.

A91-22340
DEVELOPMENT OF CAST SUPERALLOYS FOR GAS TURBINES IN CHINA
RONGZHANG CHEN and WANHUA CHEN (Institute of Aeronautical Materials, Beijing, People's Republic of China) Chinese Journal of Metal Science and Technology (ISSN 1000-3029), vol. 6, April 1990, p. 92-97. refs
Copyright

Advances in the development of cast superalloys for gas turbine applications in China over the past 30 years are briefly reviewed. It is noted that the three major developments contributing to the progress in superalloy technology were the adoption of vacuum *melting and casting processes, advances in investment casting* technology, and the introduction of directional solidification techniques. A table summarizing the chemical compositions and mechanical properties of the principal cast turbine superalloys produced in China is included. V.L.

A91-22346
MAGNETRON SPUTTERED COCRALY COATINGS ON SUPERALLOY IN738
FUHUI WANG, HANYI LOU, and LINXIANG BAI (Chinese Academy of Sciences, Institute of Corrosion and Protection of Metals, Shenyang, People's Republic of China) Chinese Journal of Metal Science and Technology (ISSN 1000-3029), vol. 6, Feb. 1990, p. 61-64. refs
Copyright

Magnetron-sputtered CoCrAlY alloy coatings on 20 x 30 x 3 mm sheets of superalloy IN738 are studied. The protective coatings are used in the hot-section components in gas turbine engines. Since no melting is involved in the sputtering process, it is possible to deposit multicomponent films of desired composition from an alloy target of the same composition. Before sputtering, the substrates are polished with waterproof emery paper of various roughnesses, peened with glass balls, and degassed with ultrasonic cleaning. In order to evaluate the oxidation and hot corrosion resistances of the sputtered CoCrAlY coating, a pack aluminide coating is selected for comparison. Subsequent to the sputtering, oxidation, and hot corrosion, the specimens are examined by optical metallography, XRD analysis, transmission electron diffraction, and electron probe microanalysis. The microstructure of the coatings, as well as the oxidation resistance and hot corrosion test results, are summarized. S.A.V.

A91-22383#
CORROSION FATIGUE CRACK GROWTH OF 30CRMNSINI2A STEEL IN AIRPLANE ENVIRONMENTS
KANGMIN NIU, MEIYING CHEN, and XUENING JU (Institute of Aeronautcal Materials, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B400-B404. In Chinese, with abstract in English. refs

The fatigue crack growth rates of 30CrMnSiNi2A high-strength steel were studied at room-temperature in standard laboratory air, low humidity air, high humidity air, 3.5 percent NaCl solution, and synthetic sump-water environments. The results show that there is no influence of moisture on d(a)/d(N). The SEM examination of specimens tested in air showed some typical features of intergranular fracture, but individual transgranular fracture was observed in moist air. There is no effect of frequency on d(a)/d(N) in air. In salt water, under free-corrosion conditions and at f = 10 Hz, the d(a)/d(N) were in agreement with the results in air, otherwise at f + 1 Hz, the d(a)/d(N) increased up to a factor of 4, dependent on Delta-K, primarily at midrange. The fracture surfaces showed classic intergranular fracture mixed with patches of transgranular fracture which was similar in both 10 Hz and 1 Hz. The result is attributed to the fact that the high strength steel is susceptible to hydrogen embrittlement. Author

A91-22884#
TITANIUM ALUMINIDES DEVELOPMENT FOR NASP AIRFRAME APPLICATIONS
DHANANJAY D. BHATT, TRENT R. LOGAN, and IRA F. VICTER (Rockwell International Corp., North American Aircraft Div., Downey, CA) AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 8 p.
(AIAA PAPER 90-5261) Copyright

The NASP program has led to intensive development of alpha-2 and gamma TiAl materials and fabrication methods for aluminide structures. These efforts are directed toward the development of TiAl airframe components for the X-30 vehicle and accordingly place a premium on high structural performance, producibility, structural integrity, and the greatest possible weight savings. A multitask parallel-path approach is being used to ascertain desirable alloy chemistries, optimize fabrication processes, and identify suitable coatings and their application methods. SPF/DB and laser welding have been investigated for alpha-2 TiAl with encouraging results, and large TiAl test structures have been produced by SPF/DB. O.C.

A91-22891#
GASDYNAMIC FEATURES OF SUPERSONIC KEROSENE COMBUSTION IN A MODEL COMBUSTION CHAMBER
S. I. BARANOVSKII, V. M. LEVIN (Moskovskii Aviatsionnyi Institut, Moscow, USSR), and V. N. AVRASHKOV AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 9 p. refs
(AIAA PAPER 90-5268) Copyright

The article is devoted to the description of methods and analysis of the results of mixture-forming bubbling systems combined with tubular micropylons, and also to obtaining the self-ignition and supersonic burning of kerosene/air mixture. The burning was investigated in a cooled model combustion chamber of rectangular cross-section. The shape of combustion chamber channel was both of constant cross section and of expansion type. The assumption of the presence of gasdynamic burning stabilization on a shock wave dominant system is substantiated. Results obtained show the quantitative and qualitative relation between the stable kerosene/air mixture burning concentration limits and the combustion chamber shape. Author

A91-23714
QUALIFICATION OF PRIMARY COMPOSITE AIRCRAFT STRUCTURES
R. S. WHITEHEAD (Northrop Corp., Aircraft Div., Hawthorne, CA) and J. L. MULLINEAUX (USAF, Wright Aeronautical Laboratories, Hawthorne, CA) IN: Advances in composite materials and structures. New York, American Society of Mechanical Engineers, 1989, p. 97-103.
Copyright

This paper presents the qualification procedures for primary composite aircraft structures. Special attention is given to the role

of material selection, the design development tests, the test conditions, the full scale static test, and the full scale durability testing in the certification process. It is recommended that the full scale static test should be regarded as the cornerstone of the qualification process and that, if the design development testing and full scale static test are successful, no full scale durability test is required for composite structures; for mixed composite/metal structures, the full scale durability tests are only required for validation fatigue critical metal parts. I.S.

N91-15322# Boeing Aerospace and Electronics Co., Seattle, WA.
X RAY COMPUTED TOMOGRAPHY OF COMPOSITES Interim Report, Jun. - Dec. 1989
RICHARD H. BOSSI, KAREN K. COOPRIDER, and GARY E. GEORGESON Jul. 1990 86 p
(Contract F33615-88-C-5404; AF PROJ. 3153)
(AD-A227227; WRDC-TR-90-4014) Avail: NTIS HC/MF A05 CSCL 14/3

The application of computed tomography (CT) for various polymer matrix composite parts was investigated. Emphasis was placed on pultruded composite parts in an effort to introduce CT as a real-time, on-line, nondestructive sampling method for the pultrusion process. In addition, several other composite parts were examined, including honeycomb panels, helicopter rotor to blades, a filament wound pressure bottle, sinewave spars, graphite/phenolic insulation, 3-D braided thermoplastics, an injection molded airfoil, and more. It has concluded that, first CT has demonstrated significant potential for reducing time and costs in development CT systems can offer advantages in research applications for composites particularly as an alternative to destructive sectioning. Based on our studies, we would recommend that efforts can be made to incorporate a medical CT system on a pultrusion system producing high criticality, aerospace components. GRA

N91-15374# Pratt and Whitney Aircraft, West Palm Beach, FL. Engineering Div.
FATIGUE AND FRACTURE OF TITANIUM ALUMINIDES Final Report, 1 Jul. 1985 - 28 Apr. 1989
D. P. DELUCA, B. A. COWLES, F. K. HAAKE, and K. P. HOLLAND Feb. 1990 270 p
(Contract F33615-85-C-5029; AF PROJ. 2420)
(AD-A226737; PW/ED/FR-20781; WRDC-TR-89-4136) Avail: NTIS HC/MF A12 CSCL 11/6

Future tactical aircraft engine designs depend heavily on advanced materials technology to meet thrust-to-weight and durability goals. Several types of materials currently under development are candidates for use in these advanced engines, including intermetallic titanium aluminides. Titanium aluminide alloys offer low density, high specific strength, and elevated temperature capabilities. If the materials are used in major structural and rotating components, these properties could significantly increase engine thrust-to-weight ratio. Monolithic titanium aluminides are currently being evaluated for static components where they offer strength and stiffness advantages at temperatures above conventional titanium alloy capability. GRA

N91-15390*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL BARRIER COATING EVALUATION NEEDS
WILLIAM J. BRINDLEY and ROBERT A. MILLER 1990 9 p Presented at the Conference on Nondestructive Evaluation of Modern Ceramics, Columbus, OH, 9-12 Jul. 1990; cosponsored by American Ceramic Society and American Society of Nondestructive Testing
(NASA-TM-103708; E-5596; NAS 1.15:103708) Avail: NTIS HC/MF A02 CSCL 11/6

A 0.025 cm (0.010 in) thick thermal barrier coating (TBC) applied to turbine airfoils in a research gas turbine engine provided component temperature reductions of up to 190 C. These impressive temperature reductions can allow increased engine operating temperatures and reduced component cooling to achieve greater engine performance without sacrificing component durability. The significant benefits of TBCs are well established in aircraft gas turbine engine applications and their use is increasing. TBCs are also under intense development for use in the Low Heat Rejection (LHR) diesel engine currently being developed and are under consideration for use in utility and marine gas turbines. However, to fully utilize the benefits of TBCs it is necessary to accurately characterize coating attributes that affect the insulation and coating durability. The purpose there is to discuss areas in which nondestructive evaluation can make significant contributions to the further development and full utilization of TBCs for aircraft gas turbine engines and low heat rejection diesel engines.
Author

N91-15418*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IN-FLIGHT AND SIMULATED AIRCRAFT FUEL TEMPERATURE MEASUREMENTS
ROGER A. SVEHLA Dec. 1990 81 p
(NASA-TM-103611; E-5765; NAS 1.15:103611) Avail: NTIS HC/MF A05 CSCL 07/4

Fuel tank measurements from ten flights of an L1011 commercial aircraft are reported for the first time. The flights were conducted from 1981 to 1983. A thermocouple rake was installed in an inboard wing tank and another in an outboard tank. During the test periods of either 2 or 5 hr, at altitudes of 10,700 m (35,000 ft) or higher, either the inboard or the outboard tank remained full. Fuel temperature profiles generally developed in the expected manner. The bulk fuel was mixed by natural convection to a nearly uniform temperature, especially in the outboard tank, and a gradient existed at the bottom conduction zone. The data indicated that when full, the upper surface of the inboard tank was wetted and the outboard tank was unwetted. Companion NASA Lewis Research Center tests were conducted in a 0.20 cubic meter (52 gal) tank simulator of the outboard tank, chilled on the top and bottom, and insulated on the sides. Even though the simulator tank had no internal components corresponding to the wing tank, temperatures agreed with the flight measurements for wetted upper surface conditions, but not for unwetted conditions. It was concluded that if boundary conditions are carefully controlled, simulators are a useful way of evaluating actual flight temperatures. Author

N91-16076# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
BUMP EXAMINATIONS OF INTEGRALLY STRENGTHENED CARBON FIBER REINFORCED PLASTIC PANELS [BEULUNTERSUCHUNGEN AN INTEGRALVERSTEIFTEN CFK-PANELS]
K. BRUNNER and K. PFISTER 20 Jul. 1990 15 p In GERMAN Presented at DGLR-Jahrestagung 1989, Hamburg, Fed. Republic of Germany, 2-4 Oct. 1989
(MBB/FE281/CFK/PUB/0013; ETN-91-98548) Copyright Avail: NTIS HC/MF A03

The appearance of bumps on carbon fiber reinforced plastic aircraft structures is investigated. Static and dynamic experiments were carried out with determination of the residual strength by means of tests which were carried out in accordance to the constructive requirements of modern high power aircraft. The bump initiation was detected with experimental measurement processes based on the failure charge. The functioning charge was shown to have no influence on the residual strength despite the high bump excess. The measurement Moire process was successfully implemented so that a routine utilization is possible. ESA

N91-16170# Human Systems Div., Brooks AFB, TX.
A COMPARISON OF THREE PROSPECTIVE ANALYTICAL METHODS FOR BENZENE ANALYSIS IN JET FUEL ENVIRONMENTS Final Report
MOHAMMAD A. HOSSAIN Aug. 1990 23 p
(AD-A227489; USAFOEHL-90-126SA00687HAE) Avail: NTIS HC/MF A03 CSCL 07/3

Accurate analysis of benzene in jet fuel has been a concern

over the past several years. The method has been used to analyze benzene in jet fuel is the NIOSH 1501 method, a method specifically designed for aromatic hydrocarbons including benzene. However, the method is not designed for analysis of benzene in jet fuel environments. At the present time there is no approved (either by NIOSH or OSHA) method for analysis of benzene in fuel environments. At the request of HQ AAC/SGPB, a study was conducted to compare three prospective analytical methods (NIOSH method 1501 (Gas Chromatography/Flame Ionization Detection (GC/FID) with packed column), modified NIOSH 1501 method (GC/FID with capillary column), and High Pressure Liquid Chromatography with Ultraviolet Detection (HPLC/UV)). Spiked charcoal tube samples as well as air samples of known concentrations of benzene in JP-4 and Stoddard Solvents were analyzed by all three methods. The test results showed that modified NIOSH 1501 and HPLC methods had good correlation between spiked and measured amount of benzene in JP-4 and Stoddard Solvent mixtures. The NIOSH 1501 method utilizing packed column over estimated the test benzene concentration indicating positive interference from other hydrocarbons present in JP 4 and Stoddard Solvents. GRA

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A91-20616
THE STABILITY OF LIGHT STRUCTURES - AN AREA OF RESEARCH WITH A TRADITION AND A FUTURE [STABILITAET VON LEICHTBAUSTRUKTUREN - EIN FORSCHUNGSGEBIET MIT TRADITION UND ZUKUNFT]
BODO GEIER and KLAUS ROHWER (DLR, Institut fuer Strukturmechanik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 40-44. In German. refs
Copyright

The study of light structures for air and space travel is discussed. Past, present, and future developments, especially those involving shells of rotation and panels, are addressed. Theoretical and experimental methods used in these studies are described. C.D.

A91-20728
A THREE-DIMENSIONAL VISUALIZATION TECHNIQUE APPLIED TO FLOW AROUND A DELTA WING
M. YODA and L. HESSELINK (Stanford University, CA) Experiments in Fluids (ISSN 0723-4864), vol. 10, no. 2-3, Dec. 1990, p. 102-108. refs
(Contract F49620-86-K-0020)
Copyright

The visualization of flows in two dimensions by using planer laser light sheets is extended to three dimensions by rapidly scanning the laser light sheet to obtain a set of 'slices' of the flow around a full-span delta wing. The leading edge vortices, which are marked with smoke, are unburst by tangential blowing around the leading edges at angles of attack in excess of 25 deg. Since the measurement period is on the order of the smallest convection time scale, a virtually instantaneous set of planar cross sections of the flow is obtained. Software is used to stack the slices and recontruct a three-dimensional surface of the smoke-seeded fluid. This surface, which corresponds to the vortices, clearly shows the qualitative effects of blowing on the delta wing flow. Author

A91-20788* Analytical Services and Materials, Inc., Hampton, VA.
AN EVALUATION OF THE PRESSURE PROOF TEST CONCEPT FOR THIN SHEET 2024-T3
D. S. DAWICKE (Analytical Services and Materials, Inc., Hampton, VA), C. C. POE, JR., J. C. NEWMAN, JR., and C. E. HARRIS (NASA, Langley Research Center, Hampton, VA) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 14, Nov. 1990, p. 101-116. refs
Copyright

The concept of pressure proof testing of fuselage structures with fatigue cracks to insure structural integrity was evaluated from a fracture mechanics viewpoint. A generic analytical and experimental investigation was conducted on uniaxially loaded flat panels with crack configurations and stress levels typical of longitudinal lap-splice joints in commercial transport aircraft fuselage. The results revealed that the remaining fatigue life after a proof test was longer than that without the proof test because of crack growth retardation due to increased crack closure. However, based on a crack length that is slightly less than the critical value at the maximum proof test stress, the minimum assured life or proof test interval must be no more than 550 pressure cycles for a 1.33 proof factor and 1530 pressure cycles for a 1.5 proof factor to prevent in-flight failures. Author

A91-20791
FRACTURE INSTABILITY OF A LAYERED CONICAL COMPOSITE RESISTING THE AERODYNAMIC LOAD
D. Y. TZOU (New Mexico, University, Albuquerque) Theoretical and Applied Fracture Mechanics (ISSN 0167-8442), vol. 14, Dec. 1990, p. 165-174. refs
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The influence of the stacking sequence of material layers on the crack instability of the layered conical composite is studied. With emphasis placed on the application to the aeronautical structures, the pressure field imposed on the structure is obtained from the aerodynamic flow field with a free stream Mach number being 2.05. The method of characteristics is used for determining the aerodynamic flow field, and the strain energy density theory is used for characterizing the crack instability which varies significantly with the stacking sequence of the material layers. It is found that the material layer with the softest stress and strain curve should be placed on the side of the inner cone tip such that the energy density established thereby can be absorbed to the most extent. The fracture instability of the three-layered conical composite is found to be geometry-dominant. Author

A91-20899
PREDICTION OF PENETRATION OF CURVED METAL STIFFENED PANELS DUE TO BIRDSTRIKE
M. R. WISNOM (Bristol, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 94, Nov. 1990, p. 313-317. Research supported by British Aerospace (Commercial Aircraft). refs
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A finite element analysis has been carried out to simulate the effect of birdstrike on concave curved metal stiffened panels representative of engine intakes. A simplified static analysis approach was adopted including the effects of nonlinear material response and large displacements. Loading was by means of an equivalent pressured derived from experimental results of bird impacts on rigid plates. Good agreement was obtained between predicted and measured bird impact velocities to cause penetration of the structure for a range of panel thicknesses, curvatures and impact angles. Author

A91-20916
RELIABILITY ANALYSIS OF STRUCTURE AND CONTROL MECHANISM OF AIRCRAFT FLAP
Y. S. FENG and L. YANG (Northwestern Polytechnical University, Xian, People's Republic of China) Computers and Structures (ISSN 0045-7949), vol. 38, no. 1, 1991, p. 21-24.
Copyright

The aircraft flap structure and its control mechanism are

considered as an entire system for analysis of the system's reliability. The significant failure modes of a flap structure are based on the following engineering criteria: the magnitude of the computational safety factors of different structural members and the possible patterns that compose failure modes. According to these significant failure modes, the failure probability of a single failure mode can be computed, and the failure probability of the flap structural system can then be solved based on these single failure probabilities. For the flap control mechanism, besides the static strength reliability, it is necessary to compute the function reliability. The reliability of the control mechanism can be synthesized from the above two kinds of reliabilities. Finally, the entire flap system failure probability can be solved by synthesis of the flap structural system failure probability and the flap control mechanism failure probability. Author

A91-20932#
METHOD OF STRENGTH EVALUATION OF RADIAL FAN ROTORS [METODA OCENY WYTRZYMALOSCIOWEJ WIRNIKOW WENTYLATOROW PROMIENIOWYCH]
WACLAW SZYC and ZYGMUNT SEKULSKI (Poznan, Politechnika, Poland) (Miedzynarodowe Kolokwium o Modelach w Projektowaniu i Konstruowaniu Maszyn, 13th, Zakopane, Poland, Apr. 25-28, 1989) Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 92, 1989, p. 275-280. In Polish.

The paper presents a method for the strength evaluation of rotors based on stress analysis and a computerized finite element method. The essential rules of a object modeling are discussed with reference to the high fidelity of mapping in the SESAM system. The values of the limiting and allowable rotational speeds are expressed. An example of the application of this method to the evaluation of a large fan rotor is presented. Author

A91-20943
FREE VIBRATION OF A CANTILEVER ANNULAR SECTOR PLATE WITH CURVED RADIAL EDGES AND VARYING THICKNESS
K. TANAKA, G. YAMADA, Y. KOBAYASHI, and S. MIURA (Hokkaido University, Sapporo, Japan) Journal of Sound and Vibration (ISSN 0022-460X), vol. 143, Dec. 8, 1990, p. 329-341. refs
Copyright

The free vibration of a cantilever annular sector plate with curved radial edges and varying thickness is analyzed by the Ritz method. For this purpose, the plate is transformed into a regular sector plate with unit outer radius by a transformation of variables. The transverse deflection of the transformed plate is expressed in a power series, the dynamical energies of the plate are evaluated, and the frequency equation of the plate is derived by the conditions for a stationary value of the Lagrangian functional. This method is applied to annular sector plates with symmetrically or unsymmetrically curved radial edges and also with varying thickness; the natural frequencies and the mode shapes are calculated numerically, and the effects of varying thickness on the vibration are studied. Author

A91-21108
MATERIALS AND PROCESSES USED FOR BONDED REPAIRS OF F/A-18 ADVANCED COMPOSITE HONEYCOMB SANDWICH STRUCTURES
DOUGLAS R. PERL (U.S. Navy, Naval Aviation Depot North Island, San Diego, CA) Society of Manufacturing Engineers, Conference on Composites in Manufacturing 9, San Diego, CA, Jan. 15-18, 1990. 23 p. refs
(SME PAPER EM90-107) Copyright

The materials and processes used for bonded repairs of F/A-18 honeycomb sandwich structures and in-service damage experience are discussed. Damage types such as delaminations, disbonds, airstream stripping, edge damage, denting, and penetration damage are outlined. The use of injection techniques for delamination damage and the use of joints for restoring strength and stiffness to skin gouges or through penetrations are reviewed, and a general repair-process flow is analyzed, with focus placed on damage/paint removal, joint machining, splicing of repair core sections, surface preparation for bonding, repair layup, and curing. The verification of the repair-process including material monitoring, process monitoring, and nondestructive inspection is covered. V.T.

A91-21109
NORTH ISLAND F/A-18 AIRCRAFT ADVANCED COMPOSITES REPAIR
GUY THERIAULT (U.S. Navy, Naval Aviation Depot North Island, San Diego, CA) Society of Manufacturing Engineers, Conference on Composites in Manufacturing 9, San Diego, CA, Jan. 15-18, 1990. 16 p.
(SME PAPER EM90-108) Copyright

Common damages occurring to F/A-18 advanced-composite components, observed at the Naval Aviation Depot North Island, as well as various repair methods practiced at this location are considered. Among the characteristic damage types are edge, impact, crash, burn, and aircraft-battle damages in addition to fluid intrusion, skin-to-core disbond damage, blown skin-to-core unbond damage, and fastener-hole damage. Nondestructive inspection techniques consisting of radiographic and ultrasonic inspections are covered, and damage tolerance is analyzed. Such repair approaches as resin injection, scarf path repairs, and moldform tools are discussed, and bolted and stepped-lap patch repairs are covered. Attention is given to external patch repairs where precured carbon/epoxy patches and patches cut from titanium-foil sheets are utilized. V.T.

A91-21115
KNOWLEDGE-BASED ENGINEERING TECHNOLOGY CASE STUDY - JET ENGINE TURBINE BLADE DESIGN
KATHY KESSEL-HUNTER (ICAD, Inc., Cambridge, MA) Society of Manufacturing Engineers, AUTOFACT '89 Conference, Detroit, MI, Oct. 30-Nov. 2, 1989. 22 p.
(SME PAPER MS89-727) Copyright

Knowledge-based engineering is presented in this study as an advanced technology addressing the need for companies to bring new high-quality products to market quickly while adapting to customer-specific needs. The evolution of design-automation technology is reviewed, and the fundamental principles of knowledge-based engineering are outlined along with its benefits. The differences between knowledge-based engineering and CAD and parametric modeling are assessed, and applications suited for knowledge-based engineering are covered. A case study involving the automated design and engineering of turbine blades for jet engines is presented with examples of the types of rules built into the resulting model, its inputs and outputs. V.T.

A91-21116
ROBOTIC ABRASIVE WATER JET CUTTING OF AEROSTRUCTURE COMPONENTS
DAREN C. DAVIS (LTV Aerospace and Defense Co., Dallas, TX) Society of Manufacturing Engineers, Conference on Nontraditional Machining, Orlando, FL, Oct. 30-Nov. 2, 1989. 14 p.
(SME PAPER MS89-812) Copyright

To reduce tooling and labor costs associated with net trimming of aerostructure components, a system has been designed and implemented which combines the flexibility and accuracy of robotics with the productivity of abrasive water jet cutting. The system is comprised of a large, six-axis gantry robot which uses specially developed abrasive water jet end effectors to trim the edge-of-panel (EOP) and integral stiffener blades. These end effectors employ compact catchers to contain the spent stream, and thereby eliminate the need for large catcher tanks commonly used in abrasive water jet cutting. The robot is offline programmed to perform trimming on large, complex contoured panels. Author

A91-21118
WATERJET/HYDROBRASIVE CUTTING IN THE AUTOMOTIVE, AEROSPACE AND APPLIANCE INDUSTRIES
DAVID F. WIGHTMAN (Ingersoll-Rand Waterjet Cutting Systems, Chicago, IL) Society of Manufacturing Engineers, Waterjet Cutting

West Conference, Los Angeles, CA, Nov. 14, 15, 1989. 12 p.
(SME PAPER MS89-833) Copyright

This paper presents the state-of-the-art manufacturing techniques of waterjet cutting. Facts on equipment, process, economics, advantages, applications, and limitations are reviewed. Waterjet/hydrobrasive is an all purpose process that requires less labor and less capital for special applications on materials of a nontraditional nature. Author

A91-21204
THE AIRCRAFT AVIONIC INTERCONNECTION SYSTEM
D. T. HARRISON (British Airways, PLC, Heathrow, England) IN: Maintenance of modern avionics systems; Proceedings of the Conference, Heathrow, England, May 9, 1989. London, Royal Aeronautical Society, 1989, p. 3.1-3.7.
Copyright

The avionic interconnection system is described as the means by which electrical power and intelligence are distributed throughout the airframe and powerplants. In addition there is no other system on the aircraft that does not rely on the avionic interconnection system. Some of the major components of the interconnection system are described including cables, conductors, insulants, fiber optics, connectors, and system protection from lightning. Other components involved in the system include circuit breakers and fuses, terminal blocks and modules, shield terminators, cable clips, loom ties, and sleeves. R.E.P.

A91-21348*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPLORATORY STUDY OF VORTEX-GENERATING DEVICES FOR TURBULENT FLOW SEPARATION CONTROL
J. C. LIN, F. G. HOWARD (NASA, Langley Research Center, Hampton, VA), and G. V. SELBY (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(AIAA PAPER 91-0042)

Flow phenomena and the relative performance associated with several devices for controlling turbulent separated flow were investigated at low speeds. Vortex-generating devices examined included: submerged vortex generators (Wheeler doublet and wishbone types), spanwise cylinders, large-eddy breakup devices (LEBU) at small angle of attack (alpha), and vortex-generator jets (VGJ). Dye flow visualization tests in a water tunnel indicated that wishbone vortex generators in the forward orientation shed horseshoe vortices; wishbone vortex generators oriented in the reverse direction and doublet vortex generators shed streamwise counterrotating vortices; a spanwise cylinder located near the wall and LEBUs at alpha = -10 deg produced eddies which rotated with the same sign as the mean vorticity in a turbulent boundary layer; and the most effective VGJs produced streamwise corotating vortices. Comparative wind tunnel tests conducted on a curved backward-facing ramp indicated that transferring momentum from the outer region of a turbulent boundary layer by embedded streamwise vortices is more effective than by transverse vortices for separation control applications. Author

A91-21351*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PROGRESS IN LASER-SPECTROSCOPIC TECHNIQUES FOR AERODYNAMIC MEASUREMENTS - AN OVERVIEW
ROBERT L. MCKENZIE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 21 p. refs
(AIAA PAPER 91-0059) Copyright

An overview is given of the capabilities and recent progress in laser-spectroscopic measurement techniques for use in aerodynamic test facilities and flight research vehicles. It includes a survey of the literature which is centered on this application of laser spectroscopy. The intended reader is the specialist in experimental fluid dynamics who is not intimately familiar with the physics or applications of laser spectroscopy. Thus, some discussion is also included of the nature of each laser-spectroscopic technique and the practical aspects of its use for aerodynamic measurements. The specific techniques reviewed include laser absorption, laser-induced fluorescence, laser Rayleigh scattering, and laser Raman scattering including spontaneous and coherent processes. Author

A91-21352*# California Inst. of Tech., Pasadena.
INTERNALLY MOUNTED THIN-LIQUID-FILM SKIN-FRICTION METER - COMPARISON WITH FLOATING ELEMENT METHOD WITH AND WITHOUT PRESSURE GRADIENT
HANS HORNUNG (California Institute of Technology, Pasadena) and JEFFREY SETO AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(Contract NAG2-621)
(AIAA PAPER 91-0060) Copyright

A new, robust oil film skin friction meter was designed and constructed. This enables skin friction measurements remotely and from within the model, as well as avoiding the need to know the location of the leading edge of the film. The instrument was tested by comparing measurements with those given by a floating element gage in a zero pressure gradient flat plate turbulent boundary layer. Both instruments agreed satisfactorily with the well-known curve for this case. Significant discrepancies between the two instruments were observed in the case of adverse and favorable pressure gradients. The discrepancies were of opposite sign for opposite-sign pressure gradients as is consistent with the error expected from floating-element gages. Additional confidence in the oil film technique is supplied by the good agreement of the behavior of the film profile with predictions from lubrication theory. Author

A91-21384#
TRENDS IN CURRENT HEAT TRANSFER COMPUTATIONS
A. F. EMERY, R. J. COCHRAN (Washington, University, Seattle), and D. W. PEPPER (Advanced Projects Research, Inc., Moorpark, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 23 p. refs
(AIAA PAPER 91-0157) Copyright

Various heat transfer problems that are currently investigated computationally, and some emerging computational trends are reviewed with reference to specific examples. In particular, attention is given to radiation problems, evaporation and interfaces, coupled and integrated problems, finite difference, finite volume, and finite element methods, and spectral elements. The discussion also covers internal forced flows and turbulence, free convection, mesh generation, adaptive grids and solvers, turbulence modeling, commercial software, and computer hardware trends. V.L.

A91-21388#
HIGH TEMPERATURE HEAT FLUX MEASUREMENTS
J. M. HAGER, L. W. LANGLEY (Vatell Corp., Christiansburg, VA), S. ONISHI, and T. E. DILLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(Contract NSF CBT-88-14364)
(AIAA PAPER 91-0165) Copyright

The Heat Flux Microsensor is a new heat flux gage system that is made using microfabrication techniques. The gages are small, have high frequency response, can measure very high heat flux, and output a voltage directly proportional to the heat flux. Because the gage is made directly on the measurement surface and the total thickness is less than 2 microns, the presence of the gage contributes negligible flow and thermal disruption. Details are given of a new gage design for use in high-temperature aerothermodynamic tests. Feed-through leads have been successfully employed to bring the signals out through the back of the surface. Survivability of gages to at least 500 C is demonstrated. Measurements are reported of heat flux in a Mach 2.4 flow. The effects of normal shock passage on the heat flux to the wall were measured. Author

A91-21391#
UNSTEADY MEASUREMENT OF SKIN FRICTION IN ADVERSE PRESSURE GRADIENT - A NEW APPROACH TO A WELL KNOWN GAUGE
KIRK J. FLUTIE and EUGENE E. COVERT (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 16 p. refs
(Contract F49620-79-C-0226; AF-AFOSR-81-0282)
(AIAA PAPER 91-0168) Copyright

A near-surface-mounted hot wire shear gauge was designed, built and calibrated in a quasi-two-dimensional channel. The time constants of the gauge are essentially the same as a hot wire anemometer so the gauge can measure unsteady shear stress. In addition to this dynamic response, the gauge has shown low thermal drift, is insensitive to pressure gradient and is virtually non-intrusive. The gauge was used to measure unsteady wall shear stress on an NACA-0012 immersed in a constant phase unsteady flow. The reduced frequency, based upon the mean displacement thickness was 0.07 or less (12 or less based upon boundary layer run). Hence the experiment corresponds to a low frequency milleu. Author

A91-21435#
SPATIAL CORRELATION VELOCIMETRY IN UNSTEADY FLOWS
P. A. FAWCETT and N. M. KOMERATH (Georgia Institute of Technology, Atlanta) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(Contract DAAL03-88-C-0003)
(AIAA PAPER 91-0271) Copyright

Two-dimensional velocity field data are obtained in steady and unsteady flow environments by Spatial Cross Correlation Velocity (SCV). Previous work on SCV is summarized. Algorithm for pixel array interpolation and moving-window averaging are used to extend the capabilities of the technique. In this paper, previous work in a water channel is extended to capture the unsteady wake of a cylinder. The first application of the technique to the flow of air in a large wind tunnel test section is demonstrated. Laminar flow over an NACA 0012 wing at a small angle of attack is first studied. Finally, the flow around the wing is captured as it executes rapid, arbitrary plunging motions. The velocity field thus captured is related to the time history of the motion of the wing. The technique is at present limited to low flow velocities by the constraints of the home-video camera system used: methods for extension to higher flow velocities are discussed. Author

A91-21519#
EIGENFUNCTION ANALYSIS OF TURBULENT MIXING PHENOMENA
M. WINTER, T. J. BARBER (United Technologies Research Center, East Hartford, CT), R. M. EVERSON, and L. SIROVICH (Brown University, Providence, RI) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0520) Copyright

An analysis of the inviscid mixing of a turbulent jet in crossflow is considered. An experimental data base is analyzed by means of a technique based on the empirical eigenfunctions. It is shown, for example, that mixing which increases with downstream distance is characterized by patterns of increasing complexity. A firm quantitative basis is presented which supports this visual perception of complexity. Author

A91-21587*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INFRARED IMAGING - A VALIDATION TECHNIQUE FOR COMPUTATIONAL FLUID DYNAMICS CODES USED IN STOVL APPLICATIONS
R. R. HARDMAN, J. R. MAHAN (Virginia Polytechnic Institute and State University, Blacksburg), M. H. SMITH, P. A. GELHAUSEN, and W. R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0675) Copyright

The need for a validation technique for computational fluid dynamics (CFD) codes in STOVL applications has led to research efforts to apply infrared thermal imaging techniques to visualize gaseous flow fields. Specifically, a heated, free-jet test facility was constructed. The gaseous flow field of the jet exhaust was characterized using an infrared imaging technique in the 2 to 5.6 micron wavelength band as well as conventional pitot tube and thermocouple methods. These infrared images are compared to computer-generated images using the equations of radiative exchange based on the temperature distribution in the jet exhaust measured with the thermocouple traverses. Temperature and velocity measurement techniques, infrared imaging, and the computer model of the infrared imaging technique are presented and discussed. From the study, it is concluded that infrared imaging techniques coupled with the radiative exchange equations applied to CFD models are a valid method to qualitatively verify CFD codes used in STOVL applications. Author

A91-21601#
BOUNDARY-LAYER TRANSITION - ANALYSIS AND PREDICTION REVISITED
TH. HERBERT (Ohio State University, Columbus) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 23 p. refs
(Contract F49620-88-C-0082; N0014-90-J-1520)
(AIAA PAPER 91-0737) Copyright

A highly efficient approach to stability analysis and spatial transition simulations in nonparallel boundary layers has been developed. Progress is being made elsewhere in the exploration of receptivity mechanisms. In light of these developments, the basic elements of the transition process and the weaknesses of current engineering methods for transition prediction are evaluated. The characteristics and validation of the new approach are briefly described and its utilization both as a research tool for analysis and as an engineering tool for prediction of transition in boundary layers are discussed. Author

A91-21722
EIGHT CHANNEL PRESSURE MEASURING SYSTEM FOR CRYOGENIC USE IN THE EUROPEAN TRANSONIC WIND-TUNNEL OVER THE TEMPERATURE RANGE 78-300 K
R. G. SCURLOCK and R. WEBB (Southampton, University, England) (International Conference on Low Temperature Electronics, 1st, Berkeley, CA, Apr. 23-26, 1990) Cryogenics (ISSN 0011-2275), vol. 30, Dec. 1990, p. 1101-1103. Research supported by the Royal Aerospace Establishment and Department of Trade and Industry. refs
Copyright

This paper describes a prototype eight-channel (four pressure and four temperature channels) computer-controlled data-logging system developed for the European Transonic Wind Tunnel. The system is capable of operations at temperatures between 77.5 and 300 K and has a precision of + or - 0.05 percent. In its present form, the data logger has 16 channel capability; in the projected modular form, a further 16 channel modules can be added, making it possible to construct a 32, 48, 64, etc., channel logger with a single digital output link, using the same local computer to control the switching, data collection, internal temperature correction, and data transmission functions. Block diagrams of the data logger are included. I.S.

A91-22188
PULSED EDDY CURRENT INSPECTION OF CRACKS UNDER INSTALLED FASTENERS
MARTIN GIBBS and JOE CAMPBELL (Staveley Instruments, Inc., Kennewick, WA) Materials Evaluation (ISSN 0025-5327), vol. 49, Jan. 1991, p. 51, 52, 54, 57-59.
Copyright

A new type of eddy current inspection technique is discussed. The technique uses a pulsed square waveform drive signal and broadband rotating Hall sensor to simplify these inspections. Advantages include reduced operator interpretation, inspection of many layers simultaneously, excellent accuracy and sensitivity,

speed and simplicity of operation, and no surface preparation. Radial position, approximate depth, and relative size of defects can quickly be determined in any layer, including the countersunk area hidden directly under a fastener head to as deep as 7 mm with nonferrous fasteners and 13 mm with ferrous fasteners. The basic technology of the system is described, the problem of dealing with off-center signals is dealt with, and the test sequence is discussed. Also discussed are the limitations to depth, edge-signal interference, relationship of gate time setting to depth, and Hall sensors and pickup calls. L.K.S.

A91-22252#
A MECHANISM OF FRETTING FATIGUE FAILURE IN THE JOINING LUG OF A WING STRUCTURE
XIANGLIN DONG (Chinese Academy of Sciences, Institute of Metal Research, Shenyang, People's Republic of China) and QINGXIANG XIN (Aircraft Structural Strength Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B420-B425. In Chinese, with abstract in English. refs

A fatigue test was carried out on a full-scale fighter wing. The aluminum alloy lug, which joins the wing and the fuselage, failed at the boundary of lug hole parallel to the fuselage. The fracture surface was observed by optical and scanning electron microscopes. There were widespread scars and extruded debris in the lug mated with a steel bushing. In the area of initial crack, wear was particularly obvious, and the crack origin caused by wear scars was observable directly. According to the condition of the stress and strain suffered by the lug, it is clear that fretting occurred between the lug hole and the bush lug surface. The lug fracture, therefore, belongs to fretting fatigue fracture. A model illustrating the mechanism of the crack origin in fretting fatigue in the joining lug is presented. Author

A91-22259#
MEASUREMENTS OF VORTICITY FIELD
ZUFENG WANG and DINGDING XIN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B480-B483. In Chinese, with abstract in English.

Vorticity spatial distributions are measured by a vorticity probe (vorticimeter) in the flow field induced by vortex shedding from the tip of a rectangular wing in various angles of attack. The vorticimeter has high sensitivity, a simpler calibration process, and ease of use. Consequently, it is capable of direct vorticity measurement and of finding the exact center trace of the vortex core. The vorticimeter measurements show a counter-rotating vortex with a center strength of 1/17 to that of the nearby main wing-tip vortex. The center vorticity is shown to decay substantially as the main wing-tip vortex moves downstream. The strengths of a pair of interacting corotational vortices are measured. The results show that both their locations and center strengths vary significantly as the two wings, each producing a tip vortex, approach each other. At a cross section of 0.3 times the chord length (c), the two corotational vortices, which are 0.195 c apart, are clearly shown to roll up. S.A.V.

A91-22267#
DETERMINATION OF RIVET DIAMETER AND EDGE DISTANCE IN AIRCRAFT RIVETED STRUCTURE
FANGLIN XIE (Shanxi Aircraft Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Oct. 1990, p. B509-B514. In Chinese, with abstract in English.

A91-22323
WEIGHT PENALTIES FOR ELECTROMAGNETIC INTERFERENCE CONTROL
RUSSELL V. CARSTENSEN (U.S. Navy, Naval Air Systems Command, Washington, DC) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 7 p. refs (SAWE PAPER 1914) Copyright

The aircraft EM environment (EME) is composed of radiations from both natural and anthropogenic sources, such as lightning static, radar, radio transmissions, etc.; in combat environments, EMP due to upper-atmosphere nuclear bursts and other nonnuclear microwaves will be especially intense. High energy radiation hazards could exist for personnel, fuel, and ordnance, in association with EMI for such instruments as avionics and radio. EMI control measures involving spatial separation, shielding, filtering, etc., are potentially associated with substantial weight gain. An account is presented of the various measures by which weight can be controlled while meeting EMI-minimization criteria. O.C.

A91-22369#
AN EQUIVALENT CALCULATION OF LOAD SPECTRUMS
FANPEI MENG and LINGFANG LI (Xian Aircraft Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B328-B333. In Chinese, with abstract in English. refs

A new method of obtaining equivalent load spectrums is presented. The load curves are divided into infinitesimal sections and the equation of S-N curve is introduced. Furthermore, the integration is performed to get the equivalent load spectrum. The method is more reasonable and more convenient in comparison with other engineering methods. It can be used in equivalent calculations of other load spectra. Author

A91-22496#
COMMENT ON 'OPTICAL BOUNDARY-LAYER TRANSITION DETECTION IN A TRANSONIC WIND TUNNEL'
P. M. H. W. VIJGEN (High Technology Corp., Hampton, VA), C. P. VAN DAM (California, University, Davis), and C. J. OBARA (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2142, 2143. refs
Copyright

A91-22752#
A CLOSED FORM SOLUTION OF STRESS INTENSITY FACTORS FOR THE SHAFT OF AEROPLANE ALL-MOVING STABILIZER WITH CORNER CRACKS EMANATING FROM A HOLE
QIZHI WANG, XING ZHANG, QINGZHI HE (Beijing University of Aeronautics and Astronautics, People's Republic of China), and BINGYI REN (Chengdu Aircraft Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A424-A432. In Chinese, with abstract in English.

Corner cracks often appear in the shaft of an aircraft all-moving stabilizer near a hole. In this paper, a new analytical-engineering method for a closed form solution of stress intensity factors for the shaft of an aircraft all-moving stabilizer (circular tube) with corner cracks near a hole is derived. The energy release rate method is used. Author

A91-22754#
NUMERICAL ANALYSES OF STRESS NEAR THE HOLE OF COMPRESSOR DISK BY BOUNDARY ELEMENT METHOD
WEIDONG WEN and DEPING GAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A440-A448. In Chinese, with abstract in English.

The boundary element method (BEM) is used to calculate the stresses near the hole of a compressor disk. Since the disk is axisymmetrical, one sector of the disk with a hole is chosen and the numerical results of FEM are used as the boundary conditions of the sector. The numerical results of BEM are compared with those of FEM. In order to obtain the stresses on the boundary, the second finite difference approach equation for the constant element is derived as well. Author

A91-23423
PANEL FLUTTER ANALYSIS USING HIGH PRECISION SHEAR FLEXIBLE ELEMENT
M. S. R. PRASAD, B. S. SARMA (Defence Research and Development Laboratory, Hyderabad, India), and T. K. VARADAN

(Indian Institute of Technology, Madras, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 144, Jan. 8, 1991, p. 9-16. refs
Copyright

A finite element formulation with use of a two-noded shear flexible element with four degrees of freedom per node is adopted to study the effects of shear deformation and rotary inertia on two-dimensional panel flutter. Exact integration is carried out for all the terms in the element matrix for both thick and thin configurations of the panel. The present study shows good agreement with the previous work for thin panels for all boundary conditions as a result of using the high precision finite element. Shear deformation and rotary inertia effects on the critical dynamic pressure, the effect of aerodynamic damping on the critical dynamic pressure, and the change in flutter mode shapes due to the increase in thickness value of the panel and its end conditions are presented in the form of graphs. Author

A91-23659*# United Technologies Research Center, East Hartford, CT.
HEAT TRANSFER IN ROTATING PASSAGES WITH SMOOTH WALLS AND RADIAL OUTWARD FLOW
J. H. WAGNER, B. V. JOHNSON (United Technologies Research Center, East Hartford, CT), and T. J. HAJEK (Pratt and Whitney Group, East Hartford, CT) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 113, Jan. 1991, p. 42-51. Research supported by the United Technologies Corp. refs
(Contract NAS3-23691)
(ASME PAPER 89-GT-272) Copyright

Experiments were conducted to determine the effects of rotation on heat transfer in turbine blade internal coolant passages. The experiments were conducted with a smooth wall, large-scale heat transfer model. The objective was to obtain the heat transfer data base required to develop heat transfer correlations and to assess computational fluid dynamic techniques for rotating coolant passages. An analysis of the governing equations showed that four parameters influence the heat transfer in rotating passages (coolant density ratio, Rossby number, Reynolds number, and radius ratio). These four parameters were varied over ranges that exceed the ranges of current open literature results, but that are typical of current and advanced gas turbine engine operating conditions. Rotation affected the heat transfer coefficients differently for different locations in the coolant passage. For example, heat transfer at some locations increased with rotation, but decreased and then increased again at other locations. Heat transfer coefficients varied by as much as a factor of five between the leading and trailing surfaces for the same test condition and streamwise location. Comparisons with previous results are presented. Author

A91-23661#
AN EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER COEFFICIENTS IN A SPANWISE ROTATING CHANNEL WITH TWO OPPOSITE RIB-ROUGHENED WALLS
M. E. TASLIM, A. RAHMAN (Northeastern University, Boston, MA), and S. D. SPRING (General Electric Co., Aircraft Engine Business Group, Lynn, MA) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 113, Jan. 1991, p. 75-82. Research supported by the General Electric Co. refs
(ASME PAPER 89-GT-150) Copyright

The heat transfer coefficient in a spanwise rotating cooling passage roughened with turbulators of different geometries is measured for a range of Reynolds numbers and three different blockage ratios. The influence of Coriolis forces on internal heat transfer is emphasized. It is concluded that a significant enhancement in heat transfer is achieved in both the stationary and rotating cases when the surfaces are roughened with ribs. For the rotating case as compared with the stationary case, a maximum increase of about 45 percent in the heat transfer coefficient is observed for a blockage ratio of 0.1333; the minimum is a decrease of about 6 percent for a blockage ratio of 0.333. The technique of using liquid crystals to determine the heat transfer coefficient is found to be effective and accurate, especially for rotating test sections. C.D.

A91-23665#
SOME OBSERVATIONS OF CHAOTIC VIBRATION PHENOMENA IN HIGH-SPEED ROTORDYNAMICS
F. F. EHRICH (GE Aircraft Engines, Lynn, MA) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 113, Jan. 1991, p. 50-57. refs
Copyright

Previous studies showed that subharmonic vibration may be encountered by a rotor when it is operated with its rotational centerline being eccentric to that of a close clearance static part, so that local contact can be made during each orbit when the rotor is excited by residual unbalance. In this paper, a simple numerical model of a Jeffcott rotor mounted on a nonlinear spring is used to show that the vibratory response in the transition zone midway between the adjacent zones of subjarmonic response has all the characteristics of chaotic behavior. It is shown that the transition from subharmonic to chaotic response has a complex substructure which involves a sequence of bifurcations of the orbit with variations in speed. This behavior was verified experimentally, using a high-speed turbomachine operating at a speed between 8 and 9 times its fundamental rotor frequency when in local contact across a clearance in the support system. I.S.

A91-23679
COMPUTERIZED PROCEDURE FOR VIBRATION DIAGNOSTICS OF AIRCRAFT BRAKES
R. L. WHEELER, III (Loral Aircraft Braking Systems, Akron, OH) and G. D. SHTEINHAUZ (PG Engineering, Akron, OH) IN: Vibration analysis - Techniques and applications; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 101-107. refs
Copyright

A procedure that is implemented in a computer program called VIBSCAN5, based on analysis of signals measured during dynamometer tests, is developed for vibration diagnostics of aircraft brakes. Analyzed data include torque, pressure, and load and acceleration signals measured on the working brake. The methodology consists of digital zero-phase filtering, searching for the time window of maximum vibration activity, and calculation of a number of dimensional and dimensionless discriminants, intended to represent the vibration events of brake stops in time and frequency domains. Application of the procedure to the data analysis of aircraft carbon brake stops shows its high diagnostics potential and usefulness for establishing a product and design database. R.E.P.

A91-23685* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SOLUTION AND SENSITIVITY ANALYSIS OF A COMPLEX TRANSCENDENTAL EIGENPROBLEM WITH PAIRS OF REAL EIGENVALUES
D. V. MURTHY (NASA, Lewis Research Center, Cleveland; Toledo, University, OH) IN: Vibration analysis - Techniques and applications; Proceedings of the Twelfth Biennial ASME Conference on Mechanical Vibration and Noise, Montreal, Canada, Sept. 17-21, 1989. New York, American Society of Mechanical Engineers, 1989, p. 229-234. Previously announced in STAR as N89-13819. refs
Copyright

This paper considers complex transcendental eigenvalue problems where one is interested in pairs of eigenvalues that are restricted to take real values only. Such eigenvalue problems arise in dynamic stability analysis of nonconservative physical systems, i.e., flutter analysis of aeroelastic systems. Some available solution methods are discussed and a new method is presented. Two computational approaches are described for analytical evaluation of the sensitivities of these eigenvalues when they are dependent on other parameters. The algorithms presented are illustrated through examples. Author

A91-23745#
FLEXURAL-FLEXURAL-TORSIONAL PARAMETRIC VIBRATIONS OF A CANTILEVER BEAM
P. F. PAI and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 395-409. refs (Contract AF-AFOSR-86-0090; F49620-87-C-0088)

Three nonlinear integrodifferential equations that describe the motion of an inextensional beam are utilized to study the planar and nonplanar responses of a fixed-free beam to a principal parametric excitation. The method of multiple scales is employed to construct a first-order uniform expansion for the interaction of three resonant modes, giving six first-order nonlinear ordinary-differential equations governing the phases and amplitudes of the modes of vibration. Results indicate that the nonlinear inertia terms produce a softening effect and play a significant role in the planar responses of high-frequency modes. For some range of parameters, the response comprises chaotically or periodically modulated motions. The dynamic behavior of a slender, long beam is of interest in connection with manipulator arms, spacecraft antennas, helicopter rotor blades, flexible satellites, and other systems that perform complex and/or large motions. R.E.P.

A91-23814
THEORY OF THE RESONANCE METHOD FOR THE QUALITY CONTROL OF ADHESIVE JOINTS [K TEORII REZONANSNOGO METODA KONTROLIA KACHESTVA KLEEVYKH SOEDINENII]
S. A. FILIMONOV (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Nerazrushaiushchego Kontrolia, Kishinev, Moldavian SSR) Defektoskopiia (ISSN 0130-3082), no. 12, 1990, p. 28-36. In Russian. refs
Copyright

A study is made of the electroacoustic channel of an ultrasonic resonance instrument for the quality control of adhesive joints in aircraft panel structures. The observed differences between the calculations and the experimental data are attributed to the effect of diffraction losses. From the standpoint of the reliability of testing, the unique correspondence between the adhesive joint quality and the frequency characteristic of the ultrasonic piezoelectric transducer is shown to be essential. V.L.

A91-23817
OPTIMIZATION OF PROCESS ROUTES IN THE REPAIR OF GAS TURBINE ENGINE COMPONENTS USING CAPILLARY TESTING [RATSIONALIZATSIIA MARSHRUTOV REMONTA DETALEI GAZOTURBINNYKH DVIGATELEI, PROVERIAEMYKH KAPILLIARNYMI METODAMI]
IU. A. GLAZKOV Defektoskopiia (ISSN 0130-3082), no. 12, 1990, p. 76-80. In Russian. refs
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Methods are proposed for the optimization of process routes in the repair of gas turbine engine components in order to improve the efficiency of capillary and complex nondestructive testing. The process is optimized by changing the sequence of repair operations, changing the operations themselves, changing test specimen preparation procedures, and changing testing techniques. Examples of repair process optimization are presented for turbine and compressor blades made of a titanium alloy. V.L.

A91-23904
OPTIMAL CONDITIONS FOR CONTROLLING THE INTENSITY OF TURBULENT FLOW BY MEANS OF SCREENS [OPTIMAL'NYE USLOVIIA UPRAVLENIIA INTENSIVNOST'IU TURBULENTNOSTI POTOKA S POMOSHCH'IU SETOK]
G. I. DERBUNOVICH, A. S. ZEMSKAIA, E. U. REPIK, and IU. P. SOSEDKO IN: Mechanics of nonuniform and turbulent flows. Moscow, Izdatel'stvo Nauka, 1989, p. 35-44. In Russian. refs
Copyright

The use of screens with a high aerodynamic resistance for reducing turbulence in wind tunnels is investigated with a view to optimizing screen geometry and location in order to achieve maximum turbulence damping with a minimum resistance. The experiments reported here were carried out at incoming flow velocities of 5-8 m/s; velocity fluctuations were measured by hot-wire anemometry. Empirical relations are obtained which make it possible to determine the optimal operating conditions of damping screens. V.L.

A91-23905
BOUNDARY LAYER THREE-DIMENSIONALITY IN PLANE COMPRESSION FLOWS [PROSTRANSTVENNOST' POGRANICHNOGO SLOIA V PLOSKOM TECHENII SZHATIIA]
V. V. ZATOLOKA and A. P. OSOVIK IN: Mechanics of nonuniform and turbulent flows. Moscow, Izdatel'stvo Nauka, 1989, p. 57-63. In Russian. refs
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Plane compression flow in an air intake was investigated experimentally in the wall region of the boundary layer by means of a visualization technique using a carbon black-oil mixture. The experiments were carried out in a supersonic wind tunnel at Mach 2 and 4 and angles of attack of 0-15 deg. The effect of free-stream Mach, angle of attack, and angle of bank on the relative flow surface is determined, and the results are presented in graphic form. V.L.

A91-23910
THREE-DIMENSIONAL BOUNDARY LAYER EFFECTS IN CONVERGENT COMPRESSION FLOWS [PROSTRANSTVENNYE EFFEKTY POGRANICHNOGO SLOIA V KONVERGENTNOM TECHENII SZHATIIA]
V. V. ZATOLOKA and G. A. KISEL' IN: Mechanics of nonuniform and turbulent flows. Moscow, Izdatel'stvo Nauka, 1989, p. 100-106. In Russian. refs
Copyright

The paper is concerned with a class of convergent compression flows derived from initially axisymmetric convergent flows by sectioning along the current surfaces, such as the external compression region AA1-LL1. Under certain conditions (e.g., pressure differential or boundary layer effects) such flows can be essentially three-dimensional. Here, results of a carbon black-oil visualization study of this class of flows are presented for a model with a central angle of 70 deg. It is shown that an important feature of convergent flow with external compression is the formation of local separation bubbles, rather than separation of the boundary layer as a whole, at Mach 1.2-1.3 or greater. V.L.

A91-23938
CALCULATION OF AVERAGED AXISYMMETRIC FLOW OF AN IDEAL GAS IN TURBOMACHINE STAGES [RASCHET OSREDNENNOGO OSESIMMETRICHNOGO POTOKA IDEAL'NOGO GAZA V STUPENIAKH TURBOMASHINY]
IU. S. KOSOLAPOV and E. IU. PROTSENKO Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Nov.-Dec. 1990, p. 141-145. In Russian. refs
Copyright

The steady-state averaged axisymmetric flow of an ideal gas in turbomachine stages is calculated using a method based on the numerical solution of equations for a current function. The method makes it possible to calculate both subsonic and transonic flow regimes. Examples of calculations are presented, and the results are compared with experimental data and analytical results in the literature. V.L.

A91-24114
AIRCRAFT STRUCTURES FOR ENGINEERING STUDENTS (2ND REVISED AND ENLARGED EDITION)
THOMAS HENRY GORDON MEGSON (Leeds, University, England) New York, Halsted Press, 1990, 581 p.
Copyright

The present work on the analysis and design of state-of-the-art aircraft structures discusses the fundamental concepts of elasticity, the torsion of solid sections, such energy methods in structural analysis as those of total potential energy and virtual work, and

the principle of superposition. Attention is then given to the bending of thin plates and the structural instability problems of Euler buckling, inelastic buckling, and flexural-torsional buckling of thin-walled columns. The analysis of actual aircraft structures encompasses the principles of stressed-skin construction for various advanced materials, the bending as well as the shearing and torsion of open and closed thin-walled beams, and the behavior of specific aircraft components. Matrix methods of structural analysis are detailed, and the relevance of these concepts to aeroelasticity and airworthiness criteria. O.C.

A91-24153#
SUPERCONVERGENCE IN TWO-DIMENSIONAL VORTEX-LATTICE METHODS
KEQIN ZHU (University of Science and Technology of China, Hefei, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Dec. 1990, p. 379-387. In Chinese, with abstract in English. refs

Superconvergence in two-dimensional vortex-lattice methods is studied. Firstly, a numerical solution is compared with an exact solution of the two-dimensional flat plate in the thin wing theory, and the discretization errors of the numerical method are analyzed. Then, a discretization scheme with superconvergence in vortex-lattice methods is derived from the Chebychev polynomial theory. Finally, superconvergence of the scheme for flow around a parabolic camber or cubic parabolic camber is verified theoretically. Author

N91-15163# Naval Weapons Center, China Lake, CA.
BROADBAND COUPLING STRUCTURES FOR MICROWAVE ARITHMETIC CIRCUITS AND PHASED ARRAYS
JOSEPH A. MOSKO *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 13 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Four specific coupling structures are introduced or are described in detail. Each has important applications now and in future systems. For example, smart skins with integrated microwave circuitry for processing and radiation may make use of a novel coupling aperture. Various rigorous design equations are available for high performance coupler designs, be they on common soft or the newer monolithic microwave integrated circuit (MMICs) capable materials. Numerical solutions are ideally suited to CAD/CAM practices and could be extended to promising newer devices involving multielement coupled transmission lines. Author

N91-15276# Novespace, Paris (France).
ECONOMICAL TEST METHOD AND EASE OF ACCESS UNDER MICROGRAVITY: THE ZERO-G CARAVELLE Abstract Only [UN MOYEN D'ESSAIS ECONOMIQUE ET D'ACCES AISE EN MICROGRAVITE: LA CARAVELLE ZERO-G]
J.-P. HOCHART and M. BRAFMAN *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 449 Sep. 1990 In FRENCH
Copyright Avail: NTIS HC/MF A23

The zero-g test aircraft Caravelle is summarized. Planes under parabolic trajectories are submitted to repeated 20 to 25 second sequences of microgravity. The level of residual gravity is in the order of 0.05 g; it is possible to achieve 0.001 g by freely floating the equipment in the flight simulator. The zero-g Caravelle has six test possibilities onboard, driven by two operators, for paths of 120 parabolas. It can be used to prepare orbital parabolic flights by simulating zero-g conditions. ESA

N91-15426*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN INTEGRATED APPROACH TO SYSTEM DESIGN, RELIABILITY, AND DIAGNOSIS
F. A. PATTERSON-HINE and DAVID L. IVERSON Dec. 1990 17 p Presented at the Digital Avionics Systems Conference, Virginia Beach, VA, 15-18 Oct. 1990
(NASA-TM-102861; A-90272; NAS 1.15:102861) Avail: NTIS HC/MF A03 CSCL 13/2

The requirement for ultradependability of computer systems in future avionics and space applications necessitates a top-down, integrated systems engineering approach for design, implementation, testing, and operation. The functional analyses of hardware and software systems must be combined by models that are flexible enough to represent their interactions and behavior. The information contained in these models must be accessible throughout all phases of the system life cycle in order to maintain consistency and accuracy in design and operational decisions. One approach being taken by researchers at Ames Research Center is the creation of an object-oriented environment that integrates information about system components required in the reliability evaluation with behavioral information useful for diagnostic algorithms. Procedures have been developed at Ames that perform reliability evaluations during design and failure diagnoses during system operation. These procedures utilize information from a central source, structured as object-oriented fault trees. Fault trees were selected because they are a flexible model widely used in aerospace applications and because they give a concise, structured representation of system behavior. The utility of this integrated environment for aerospace applications in light of our experiences during its development and use is described. The techniques for reliability evaluation and failure diagnosis are discussed, and current extensions of the environment and areas requiring further development are summarized. Author

N91-15597 ESDU International Ltd., London (England).
FATIGUE OF ALUMINIUM ALLOY JOINTS WITH VARIOUS FASTENER SYSTEMS. HIGH LOAD TRANSFER Abstract Only
Sep. 1990 32 p
(ESDU-90018; ISBN-0-85679-744-8; ISSN-0958-0379) Avail: ESDU

This Data Item 90018, an addition to the Fatigue-Endurance Data Sub-series, presents the results of over 150 axial load fatigue tests extracted from the literature on the joints under variable amplitude loading (the FALSTAFF loading sequence). A high load transfer joint is one in which more than 30 percent of the axial load is transferred between members and many joints in aircraft wings fall in that category. Details are given of the seven joint designs tested intended to simulate typical structural features, together with details of the two countersunk proprietary fasteners used. Data for the alloys, which were 7050-T76 and 7050-T7651, are included. Tests were made with both clearance-fit and interference-fit fasteners and in some cases the holes were also treated to induce compressive stresses. The effects of these differences are discussed. Despite being tested under axial load, in some designs due to the asymmetric distribution of stresses a bending moment, termed secondary bending, was induced in the region of the fasteners. Using strain gauges the secondary bending was measured and the results are presented in terms of the peak stress, including that due to secondary bending, plotted against FALSTAFF cycles. In addition, results are tabulated for the percentage of load transferred and the measured values of secondary bending. It is noted that to use the results for other joints, secondary bending must be taken into account, and that caution must be observed if the results are applied to joints markedly different in geometry or size from those tested. ESDU

N91-15598*# Sverdrup Technology, Inc., Brook Park, OH.
ESTIMATION OF THE ENGINEERING ELASTIC CONSTANTS OF A DIRECTIONALLY SOLIDIFIED SUPERALLOY FOR FINITE ELEMENT STRUCTURAL ANALYSIS Final Report
ALI ABDUL-AZIZ and SREERAMESH KALLURI Jan. 1991 15 p
(Contract NAS3-25266)
(NASA-CR-187036; E-5832; NAS 1.26:187036) Avail: NTIS HC/MF A03 CSCL 20/11

The temperature-dependent engineering elastic constants of a directionally solidified nickel-base superalloy were estimated from the single-crystal elastic constants of nickel and MAR-MOO2 superalloy by using Wells' method. In this method, the directionally solidified (columnar-grained) nickel-base superalloy was modeled as a transversely isotropic material, and the five independent elastic

constants of the transversely isotropic material were determined from the three independent elastic constants of a cubic single crystal. Solidification for both the single crystals and the directionally solidified superalloy was assumed to be along the (001) direction. Temperature-dependent Young's moduli in longitudinal and transverse directions, shear moduli, and Poisson's ratios were tabulated for the directionally solidified nickel-base superalloy. These engineering elastic constants could be used as input for performing finite element structural analysis of directionally solidified turbine engine components. Author

N91-15604*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPARISON OF FATIGUE LIFE PREDICTION METHODOLOGIES FOR ROTORCRAFT
R. A. EVERETT, JR. (Army Aviation Research and Development Command, Hampton, VA.) Dec. 1990 32 p Submitted for publication
(NASA-TM-102759; NAS 1.15:102759; AVSCOM-TR-90-B-011) Avail: NTIS HC/MF A03 CSCL 20/11

Because of the current U.S. Army requirement that all new rotorcraft be designed to a 'six nines' reliability on fatigue life, this study was undertaken to assess the accuracy of the current safe life philosophy using the nominal stress Palmgrem-Miner linear cumulative damage rule to predict the fatigue life of rotorcraft dynamic components. It has been shown that this methodology can predict fatigue lives that differ from test lives by more than two orders of magnitude. A further objective of this work was to compare the accuracy of this methodology to another safe life method called the local strain approach as well as to a method which predicts fatigue life based solely on crack growth data. Spectrum fatigue tests were run on notched (k(sub t) = 3.2) specimens made of 4340 steel using the Felix/28 tests fairly well, being slightly on the unconservative side of the test data. The crack growth method, which is based on 'small crack' crack growth data and a crack-closure model, also predicted the fatigue lives very well with the predicted lives being slightly longer that the mean test lives but within the experimental scatter band. The crack growth model was also able to predict the change in test lives produced by the rainflow reconstructed spectra. Author

N91-15605*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROBABILISTIC FATIGUE METHODOLOGY FOR SIX NINES RELIABILITY
R. A. EVERETT, JR., F. D. BARTLETT, JR., and WOLF ELBER (Army Aviation Research and Development Command, Hampton, VA.) Dec. 1990 53 p Submitted for publication
(NASA-TM-102757; NAS 1.15:102757; AVSCOM-TR-90-B-009) Avail: NTIS HC/MF A04 CSCL 20/11

Fleet readiness and flight safety strongly depend on the degree of reliability that can be designed into rotorcraft flight critical components. The current U.S. Army fatigue life specification for new rotorcraft is the so-called six nines reliability, or a probability of failure of one in a million. The progress of a round robin which was established by the American Helicopter Society (AHS) Subcommittee for Fatigue and Damage Tolerance is reviewed to investigate reliability-based fatigue methodology. The participants in this cooperative effort are in the U.S. Army Aviation Systems Command (AVSCOM) and the rotorcraft industry. One phase of the joint activity examined fatigue reliability under uniquely defined conditions for which only one answer was correct. The other phases were set up to learn how the different industry methods in defining fatigue strength affected the mean fatigue life and reliability calculations. Hence, constant amplitude and spectrum fatigue test data were provided so that each participant could perform their standard fatigue life analysis. As a result of this round robin, the probabilistic logic which includes both fatigue strength and spectrum loading variability in developing a consistant reliability analysis was established. In this first study, the reliability analysis was limited to the linear cumulative damage approach. However, it is expected that superior fatigue life prediction methods will ultimately be developed through this open AHS forum. To that end, these preliminary results were useful in identifying some topics for additional study. Author

N91-15607*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
DEVELOPMENT AND APPLICATION OF A TECHNIQUE FOR REDUCING AIRFRAME FINITE ELEMENT MODELS FOR DYNAMICS ANALYSIS
MOSTAFA HASHEMI-KIA and MOSTAFA TOOSSI Oct. 1990 132 p
(Contract NAS1-17498)
(NASA-CR-187448; NAS 1.26:187448) Avail: NTIS HC/MF A07 CSCL 20/11

A computational procedure for the reduction of large finite element models was developed. This procedure is used to obtain a significantly reduced model while retaining the essential global dynamic characteristics of the full-size model. This reduction procedure is applied to the airframe finite element model of AH-64A Attack Helicopter. The resulting reduced model is then validated by application to a vibration reduction study. Author

N91-16206# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
RESULTS OF THE KANSAS CITY 1989 TERMINAL DOPPLER WEATHER RADAR (TDWR) OPERATIONAL EVALUATION TESTING
J. E. EVANS, ed. 17 Aug. 1990 87 p
(Contract DTFA01-83-4-10579)
(AD-A228784; ATC-171; DOT/FAA/NR-90/1) Avail: NTIS HC/MF A05 CSCL 17/9

The Terminal Doppler Weather Radar (TDWR) testbed was used at the Kansas City International (KCI) airport during the summer of 1989. The objective was to test and refine previous tested techniques for the automatic detection of low-altitude wind shear phenomena (specifically microbursts and gun fronts) and heavy precipitation in a midwest weather environment, as well as to assess possible new products such as storm movement predictions. A successful operation evaluation of the TDWR products took place at the KCI tower and terminal radar control room (TRACON). Several supervisor and controller display refinements were assessed as effective. The system was successful in terms of aircraft at KCI avoiding wind shear encounters during the operational period, and it was assessed as very good in usefulness for continuing operation by the KCI air traffic control (ATC) personnel. The probability of detection for microbursts was substantially better than that in Denver. However, the false-alarm probability was found to be substantially higher in Kansas City due to a combination of weather and clutter phenomena. By optimizing the site-adaptation capabilities of the TDWR meteorological and data quality algorithms, the required false-alarm probability was achieved. The gust front performance was generally poorer than in Denver due to a combination of unfavorable radar-airport-gust front geometry of false alarms induced by low-level jets. Gust front algorithm refinements which should provide improved performance are discussed. GRA

N91-16281 Council for National Academic Awards (England).
FAR-FIELD BOUNDARIES AND THEIR NUMERICAL TREATMENT Ph.D. Thesis
S. KARNI 1989 227 p
Avail: Univ. Microfilms Order No. BRDX89813

Many computational problems of theoretical and practical interest are not naturally bounded by physical boundaries. Aerodynamic examples include flow calculations past airfoils or past wing-body configurations, semi-bounded channel flows. Other examples include simulations of turbomachinery flows, problems in underwater acoustics. To obtain a numerical solution, the problem has first to be converted to a finite region by introducing an artificial boundary at some finite distance. Boundary conditions must be specified at the artificial boundary for well-posedness of the truncated problem. An open boundary across which the fluid flows are simulated should ideally allow outgoing waves to pass through without generating reflections. A thorough numerical study is

presented for the efficiency of several widely used boundary conditions in absorbing outgoing waves. The key parameters upon which the level of absorption at the boundaries depends, are examined and the limitations of some of the existing recipes expressed. Substantial reflections may occur even under conditions which are considerably milder than those encountered in practical calculations. Two closely related far field modifications are derived and analyzed: slowing down the outgoing waves; and attenuating the outgoing waves. Analytic conditions are derived to ensure that no reflections are generated due to the change of coefficients in the governing equations. Reflection analysis is also performed on the discrete level. The modifications are extended to two space dimensions and are applied to a variety of one and multidimensional test problems. Dissert. Abstr.

N91-16293# Calspan Corp., Arnold AFS, TN.
INVESTIGATION OF THE INFLUENCE OF CONSTANT ADVERSE PRESSURE GRADIENTS ON LAMINAR BOUNDARY-LAYER STABILITY AT MACH NUMBER 8 Final Report, 7-11 May 1990
J. C. DONALDSON, J. P. GRUBB, and D. W. SINCLAIR AEDC Oct. 1990 59 p Sponsored by AF
(AD-A228231; AEDC-TSR-90-V13) Avail: NTIS HC/MF A04 CSCL 20/4

Measurements of fluctuating flow and mean flow parameters were made in the boundary layer on each of two axisymmetric, constant pressure gradient bodies in an investigation of the influence of adverse pressure gradients on the stability of a laminar boundary layer in hypersonic flow. Each test article was slender, constant pressure gradient flare combined with a sharp cone forebody with a 7-deg half angle. The test articles differed in the magnitude of the pressure gradient. The flow fluctuation measurements were made using constant current hot-wire anemometry techniques. Boundary layer profiles and model surface conditions were measured to supplement the hot-wire data. Testing was done at Mach number 8 with a free-stream unit Reynolds number of 1.0-million per foot. The test equipment, test techniques, and the data acquisition and reduction procedures are described. The test was the ninth in a series of efforts which have investigated various aspects of hypersonic boundary layer stability. GRA

N91-16330# United Technologies Research Center, East Hartford, CT.
ADVANCED STRUCTURAL INSTRUMENTATION, VOLUME 2 Final Report, Feb. 1983 - Nov. 1989
A. J. DENNIS and GRAHAM B. FULTON 11 Jun. 1990 171 p
(Contract F33615-83-C-2330; AF PROJ. 3066)
(AD-A227473; UTRC-R-89-2330-VOL-2;
WRDC-TR-90-2020-V2-VOL-2) Avail: NTIS HC/MF A08 CSCL 21/5

The results are presented of the development and tests of a variety of steady state strain and temperature sensors specifically aimed at application in hot sections of advanced gas turbines. In each case, the sensors have shown success in the laboratory, and tests and results described herein were designed to simulate the actual turbine environment. Most of the testing was carried out in the UTRC vacuum spin rig which was able to achieve speeds and temperatures characteristic of advanced gas turbines. Volume 1 is an overview of the sensors, physical description, summary comparison of results and conclusions and recommendations. Volume 2 gives the details of the sensor fabrication and installation as well as evaluation of the data acquired. The details are given of a specific sensor tested in this program. Temperature sensors tested in the present program include conventional wire thermocouples and an advanced type of thin film thermocouple deposited directly on the test piece. The temperature measuring capability of twin core optical fiber sensor technology was also demonstrated. Remote sensing of temperature was achieved with a thermographic phosphor technique, and optical pyrometry was used as a control throughout the program. Additionally, the feasibility of advanced concept heat flux sensors on a turbine blade was demonstrated. GRA

N91-16382# Implant Sciences Corp., Danvers, MA.
WEAR MEASUREMENT OF CERAMIC BEARINGS IN GAS TURBINES Final Report, Aug. 1989 - Mar. 1990
A. J. ARMINI and S. N. BUNKER Mar. 1990 58 p
(Contract F33615-89-C-2942; AF PROJ. 3005)
(AD-A227505; WRDC-TR-90-2078) Avail: NTIS HC/MF A04 CSCL 13/9

The objective was to determine the feasibility of measuring ceramic bearing wear in real time. The method chosen is to selectively introduce a radioactive tag into the surface of a ceramic part and to measure the wear amount by monitoring the strength of the tagging activity as the test progresses. Although this method has been used for many years in the automobile and heavy machinery industries, it has not yet been used to measure the extremely minute amounts of wear which are experienced by ball bearings. This program was analytical in nature, and its principal task was to show the feasibility and accuracy of such a technique applied to Si3N4 and SiC ceramic bearing components. In addition the goal was to develop the analytical theory and operational techniques needed for wear tests. GRA

N91-16407*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FINITE ELEMENT THERMO-VISCOPLASTIC ANALYSIS OF AEROSPACE STRUCTURES
AJAY K. PANDEY, PRAMOTE DECHAUMPHAI, and EARL A. THORNTON (Virginia Univ., Charlottesville.) Nov. 1990 23 p Presented at the 1st Thermal Structures Conference, Charlottesville, VA, 13-15 Nov. 1990 Previously announced in IAA as A91-16034
(NASA-TM-102761; NAS 1.15:102761) Avail: NTIS HC/MF A03 CSCL 20/11

The time-dependent thermo-viscoplastic response of aerospace structures subjected to intense aerothermal loads is predicted using the finite-element method. The finite-element analysis uses the Bodner-Partom unified viscoplastic constitutive relations to determine rate-dependent nonlinear material behavior. The methodology is verified by comparison with experimental data and other numerical results for a uniaxially-loaded bar. The method is then used (1) to predict the structural response of a rectangular plate subjected to line heating along a centerline, and (2) to predict the thermal-structural response of a convectively-cooled engine cowl leading edge subjected to aerodynamic shock-shock interference heating. Compared to linear elastic analysis, the viscoplastic analysis results in lower peak stresses and regions of plastic deformations. Author

13

GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A91-20695* Air Force Geophysics Lab., Hanscom AFB, MA.
OBSERVATIONS OF SEVERE TURBULENCE NEAR THUNDERSTORM TOPS
K. C. PANTLEY (USAF, Geophysics Laboratory, Hanscom AFB, MA) and PETER F. LESTER (San Jose State University, CA) Journal of Applied Meteorology (ISSN 0894-8763), vol. 29, Nov. 1990, p. 1171-1179. refs
(Contract NCC2-315)
Copyright

Data derived from the flight tapes of two airliners that experienced severe turbulence near thunderstorm tops are used to produce quantitative descriptions of the turbulence and its environment. The likely turbulence-producing processes include a three-dimensional turbulent wake in the lee of a squall line and an updraft in the top of a thunderstorm. Results suggest that

current procedures for using surface and airborne weather radar for routing aircraft near thunderstorm tops should be reexamined. Also, although useful rules for safe flight near thunderstorm tops already exist, there is evidence that they are not universally applied. Author

A91-21252
ADVANCED U.S. MILITARY AIRCRAFT BATTERY SYSTEMS
RICHARD A. FLAKE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and MICHAEL D. ESKRA (Johnson Controls, Inc., Advanced Battery Business Unit, Milwaukee, WI) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 6 p.
(SAE PAPER 901054) Copyright

While most USAF aircraft currently use vented Ni-Cd for dc electrical power and emergency power, as well as the powering of lights and instruments prior to engine starting, these batteries have high maintenance requirements, low reliability, and no built-in testing capability with which to check battery health prior to flight. The USAF Wright R&D Center accordingly initiated its Advanced Maintenance-Free NiCd Battery System development program in 1986, in order to develop a sealed Ni-Cd battery which would remain maintenance-free over a period of three years. Attention is being given to a high power bipolar battery design in which there are no individual cell cases or cell interconnects. O.C.

A91-21530#
A PROGRAM TO IMPROVE AIRCRAFT ICING FORECASTS - STATUS REPORT
WAYNE R. SAND and MARCIA K. POLITOVICH (NCAR, Boulder, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research supported by NOAA and NSF. refs
(Contract DTFA01-90-Z-02005)
(AIAA PAPER 91-0557) Copyright

In October 1989, the Federal Aviation Administration (FAA) initiated a six-year program to improve aircraft icing forecasts. As part of this program, two months of field studies were conducted in the Denver area during winter 1990. This paper provides a status report on that effort, gives a summary of the observations, and presents plans for an expanded field study in 1991. Author

A91-21712* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE DYNAMICS OF THE STRATOSPHERIC POLAR VORTEX AND ITS RELATION TO SPRINGTIME OZONE DEPLETIONS
MARK R. SCHOEBERL (NASA, Goddard Space Flight Center, Greenbelt, MD) and DENNIS L. HARTMANN (Washington, University, Seattle) Science (ISSN 0036-8075), vol. 251, Jan. 4, 1991, p. 46-52. refs
Copyright

Recent aircraft observations have determined the structure of polar vortices during winter and their relationship to polar ozone depletions, based on high dynamical isolation and the extremely low temperatures required for stratospheric cloud formation. The aircraft data reveal large gradients of potential vorticity and concentrations of conservative trace species at the transition from high-latitude to polar air, implying that the inward mixing of heat and constituents is strongly inhibited, and that the perturbed polar stratospheric chemistry associated with the ozone hole is isolated from the rest of the stratosphere until the vortex breaks up in late spring. It is therefore the overall polar vortex which limits the annual polar ozone depletions' maximum area-coverage. O.C.

N91-15657# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
FINE SCALE ANALYSIS OF THE KINEMATIC, DYNAMIC AND THERMODYNAMIC FEATURES OF A MULTIPLE MICROBURST-PRODUCING STORM M.S. Thesis - St. Louis Univ.
BRADLEY TODD REGAN 1990 104 p
(AD-A227733; AFIT/CI/CIA-90-083) Avail: NTIS HC/MF A06
CSCL 04/2

The Joint Airport Weather Studies (JAWS) project, designed to investigate low-level wind shear (LLWS) and its impact on aviation, provides abundant knowledge of the phenomena of microbursts. Observational data collected by Doppler radar during the experiment is providing a better understanding of microburst/LLWS structure and Doppler analysis techniques. This understanding is important because deployment of Doppler radar at the national level makes it the principle instrument of regional (meso-scale) forecasting. Microbursts are multi-faceted features of some thunderstorms and occur under a myriad of circumstances. Meteorologists are studying their history, evolution and outcome. Microburst detection, warning, notification and general aviation education are becoming paramount tissues in light of todays ever increasing air travel. The atmospheric state at the time of the microburst and boundary layer interaction exemplify the planetary cascade of energy as it occurs daily. Studies of this kind are necessary to focus attention upon the consequential impacts of these weather phenomena. Data are presented for several mircoburst events which occurred on 5 August 1982. GRA

N91-16466*# National Aeronautics and Space Administration, Washington, DC.
THE ATMOSPHERIC EFFECTS OF STRATOSPHERIC AIRCRAFT: A TOPICAL REVIEW
HAROLD S. JOHNSTON (California Univ., Berkeley.), M. J. PRATHER, and R. T. WATSON Jan. 1991 32 p
(NASA-RP-1250; NAS 1.61:1250) Avail: NTIS HC/MF A03
CSCL 13/2

In the late 1960s the aircraft industry became interested in developing a fleet of supersonic transports (SSTs). Between 1972 and 1975, the Climatic Impact Assessment Program (CIAP) studied the possible environmental impact of SSTs. For environmental and economic reasons, the fleet of SSTs was not developed. The Upper Atmosphere Research Program (UARP) has recently undertaken the responsibility of directing scientific research needed to assess the atmospheric impact of supersonic transports. The UARP and the High-Speed Research Program asked Harold Johnston to review the current understanding of aircraft emissions and their effect on the stratosphere. Johnston and his colleagues have recently re-examined the SST problem using current models for stratospheric ozone chemistry. A unique view is given here of the current scientific issues and the lessons learned since the beginning of CIAP, and it links the current research program with the assessment process that began two years ago. Author

N91-16467*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE ATMOSPHERIC EFFECTS OF STRATOSPHERIC AIRCRAFT: A CURRENT CONSENSUS
A. R. DOUGLASS, M. A. CARROLL, W. B. DEMORE, J. R. HOLTON, I. S. A. ISAKSEN, H. S. JOHNSTON, and M. K. W. KO (Atmospheric and Environmental Research, Inc., Cambridge, MA.) Jan. 1991 46 p
(NASA-RP-1251; NAS 1.61:1251) Avail: NTIS HC/MF A03
CSCL 13/2

In the early 1970's, a fleet of supersonic aircraft flying in the lower stratosphere was proposed. A large fleet was never built for economic, political, and environmental reasons. Technological improvements may make it economically feasible to develop supersonic aircraft for current markets. Some key results of earlier scientific programs designed to assess the impact of aircraft emissions on stratospheric ozone are reviewed, and factors that must be considered to assess the environmental impact of aircraft exhaust are discussed. These include the amount of nitrogen oxides injected in the stratosphere, horizontal transport, and stratosphere/troposphere assessment models are presented. Areas in which improvements in scientific understanding and model representation must be made to reduce the uncertainty in model calculations are identified. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A91-20506
NEW GENERAL GUIDANCE METHOD IN CONSTRAINED OPTIMAL CONTROL. I - NUMERICAL METHOD
B. KUGELMANN (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) and H. J. PESCH (Muenchen, Technische Universitaet, Munich; Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 67, Dec. 1990, p. 421-435. Research supported by DFG. refs
Copyright

A very fast numerical method is developed for the computation of neighboring optimum feedback controls. This method is applicable to a general class of optimal control problems (for example, problems including inequality constraints and discontinuities) and needs no on-line computation, except for one matrix-vector multiplication. The method is based on the so-called accessory minimum problem. The necessary conditions for this auxiliary optimal control problem form a linear multipoint boundary-value problem with linear jump conditions, which is especially well suited for numerical treatment. In the second part of this paper, the performance of the guidance scheme is shown for the heating-constrained cross-range maximization problem of a space-shuttle-orbiter-type vehicle. Author

A91-20999* Sparta, Inc., Laguna Hills, CA.
THE DEVELOPMENT OF A FLIGHT TEST ENGINEER'S WORKSTATION FOR THE AUTOMATED FLIGHT TEST MANAGEMENT SYSTEM
DAVID M. TARTT, MARLE D. HEWETT (Sparta, Inc., Laguna Hills, CA), EUGENE L. DUKE, JAMES A. COOPER (NASA, Flight Research Center, Edwards, CA), and RANDAL W. BRUMBAUGH (PRC Kentron, Inc., Aerospace Technologies Div., Edwards, CA) IN: Society of Flight Test Engineers, Annual Symposium, 20th, Reno, NV, Sept. 18-21, 1989, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1989, p. 5.2-1 to 5.2-12.
Copyright

The Automated Flight Test Management System (ATMS) is being developed as part of the NASA Aircraft Automation Program. This program focuses on the application of interdisciplinary state-of-the-art technology in artificial intelligence, control theory, and systems methodology to problems of operating and flight testing high-performance aircraft. The development of a Flight Test Engineer's Workstation (FTEWS) is presented, with a detailed description of the system, technical details, and future planned developments. The goal of the FTEWS is to provide flight test engineers and project officers with an automated computer environment for planning, scheduling, and performing flight test programs. The FTEWS system is an outgrowth of the development of ATMS and is an implementation of a component of ATMS on SUN workstations. R.E.P.

A91-21235
CURRENT RESEARCH ON SCHEDULERS FOR AEROSPACE INDUSTRY SOFTWARE
RICHARD M. GREATHOUSE and KELLY L. SHIPLEY (U.S. Army, Aviation Systems Command, Saint Louis, MO) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 9 p. refs
(SAE PAPER 901014) Copyright

Reconstruction of existing software data for U.S. Army Aviation Systems Command (AVSCOM) cost analysis is presented. The data in both quantitative and statistical terms are developed. Four formal cost estimating models are included: (1) software engineering cost model (SECOMO); (2) software architecture sizing estimating tool (SASET); (3) parametric review of information for costing and evaluation (PRICE-S); and (4) Ray's enhanced version of intermediate COCOMO (REVIC). Attempts to identify possible causes of variances between the models and the actual calendar months reported in each study are reported. Y.P.Q.

A91-21326# Rockwell International Science Center, Thousand Oaks, CA.
RESEARCH TO APPLICATION: SUPERCOMPUTING TRENDS FOR THE 90'S - OPPORTUNITIES FOR INTERDISCIPLINARY COMPUTATIONS
VIJAYA SHANKAR (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 24 p. Research supported by NASA. refs
(AIAA PAPER 91-0002) Copyright

The progression of supercomputing is reviewed from the point of view of computational fluid dynamics (CFD), and multidisciplinary problems impacting the design of advanced aerospace configurations are addressed. The application of full potential and Euler equations to transonic and supersonic problems in the 70s and early 80s is outlined, along with Navier-Stokes computations widespread during the late 80s and early 90s. Multidisciplinary computations currently in progress are discussed, including CFD and aeroelastic coupling for both static and dynamic flexible computations, CFD, aeroelastic, and controls coupling for flutter suppression and active control, and the development of a computational electromagnetics technology based on CFD methods. Attention is given to computational challenges standing in a way of the concept of establishing a computational environment including many technologies. V.T.

A91-21624#
COUPLED LEWICE/NAVIER-STOKES CODE DEVELOPMENT
J. ERIC HOLCOMB (Boeing Aerospace and Electronics, Seattle, WA) and BAHMAN NAMDAR (Boeing Commercial Airplanes, Seattle, WA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0804) Copyright

An existing Boeing-developed Navier-Stokes/grid generation computer code package has been integrated with the water droplet trajectory and thermal routines from the NASA Lewis ice accretion prediction computer code (LEWICE), in an effort to overcome the limitations of the potential flow solver used in the standard version of LEWICE. The flow code solves the Reynolds-averaged Navier-Stokes equations with the 1985 MacCormack implicit finite volume algorithm, and a two-equation (k-epsilon) turbulence model. The grid generator uses an efficient parabolic/elliptic method. A limited number of airfoil test cases, with and without icing, have been run to validate the new code package. These test cases include RAE 2822, NACA 0012, and Boeing 737-200 airfoils. Preliminary results appear encouraging, although there are some differences between calculations and test data at higher angles of attack, and not enough cases have yet been run with ice accretion for proper validation. Author

A91-22325
IMPP - THE INTEGRATED MASS PROPERTIES PROGRAM
BRAD FISCHER (Lockheed Aeronautical Systems Co., Burbank, CA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 41 p.
(SAWE PAPER 1894) Copyright

The user-friendly, expandable data base Integrated Mass Properties Program (IMPP) was developed in order to meet the weight tracking and reporting requirements of such projects as the Advanced Tactical Fighter. IMPP operates via a series of menus, with users responding to on-screen prompts with one-character selections from a list. While some options allow the user to prepare data for incorporation into the data base, others allow the user to retrieve data and present it in such formats as MIL-STD-1374A, as well as the format of internal status reports.

A representative work session with the IMPP is presented, together with illustrative inputs and outputs. O.C.

A91-22373#
A MAXIMUM LIKELIHOOD METHOD FOR FLIGHT TEST DATA COMPATIBILITY CHECK
ZHONGKE SHI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B354-B360. In Chinese, with abstract in English.

An efficient maximum likelihood method for the estimation of instrumentation errors for flight is presented. In order to get high accuracy of bias estimation and to decrease the effects of measurement noises, the least-squares and shifted Chebyshev series method are applied to smoothing the measurements of roll rate, yaw rate, pitch rate, and accelerations. The methods for determining sensitivity matrix and initial values of parameters are developed, and U-D factorization is devoted to computing the 'ill-conditioned' matrix of parameter covariance. Simulation and actual application to two kinds of aircraft show that the method presented can give accurate estimation results of instrumentation errors in a flight test system, and is more efficient than the ordinary ones. Author

A91-22756#
AN ADAPTIVE FILTER FOR TRACKING THE MANEUVERING TARGET
PEIZHANG JIA (Chinese Academy of Sciences, Institute of Systems Science, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A456-A464. In Chinese, with abstract in English. refs

The tracking problem for the maneuvering target is studied and an adaptive filter is shown in the paper. In the adaptive filter different dynamical models are adopted depending on the flight states of the aircraft. The optimal detecting method, which not only detects maneuver of the aircraft but also determines the fashion of the maneuver based on the three typical flight states of the aircraft, is presented. Author

A91-22758#
AN IDENTIFICATION METHOD OF FAST TIME VARYING PARAMETERS ADAPTED TO AIRCRAFT CONTROL SYSTEMS
XINHAI CHEN, XIAOMING YAN, and YANJUN LI (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Sept. 1990, p. A474-A479. In Chinese, with abstract in English.

In adaptive control systems, specifically in aircraft control systems, there is often the problem of identifying fast time varying parameters. Using broken line to approximate time-varying parameter and based on the least squares principle, an identification algorithm which is simple for calculation with perfect accuracy is derived. Simulations for control systems of antitank missiles are carried out. Author

A91-22953#
IDENTIFICATION OF TIME DELAYS IN FLIGHT MEASUREMENTS
J. BLACKWELL and R. A. FEIK (Defence Science and Technology Organisation, Aeronautical Research Laboratory, Melbourne, Australia) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 132-139. refs
Copyright

A computer program has been developed for the maximum likelihood estimation of parameters in general nonlinear systems. Sensitivity matrix elements are calculated numerically, overcoming the need for explicit sensitivity equations. Parameters such as break points and time delays are successfully determined using simulated data. Two examples using aircraft flight data are shown to demonstrate the identification of multiple time delays concurrently with other parameters. Author

A91-23742#
ADAM 2.0 - AN ASE ANALYSIS CODE FOR AIRCRAFT WITH DIGITAL FLIGHT CONTROL SYSTEMS
J. SALLEE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 329-344. refs

This paper presents an overview of a new computer code used for the analysis of the aeroservoelastic stability of an aircraft employing a digital flight control system. The computer code, ADAM 2.0, evolved as a result of the modifications and improvements made to another original Air Force computer code, ADAM. The modifications result from changes made to the original procedure for integrating the model of the digital flight control system with the aeroelastic model of the aircraft. In addition, discretization schemes are compared. The major improvements arise from the techniques used to develop analytic functions of the unsteady generalized aerodynamic forces. These improvements are demonstrated together with results of a preliminary analysis of a current aircraft. Author

N91-15715# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
COMPUTER AIDED SYSTEM DESIGN AND SIMULATION
Aug. 1990 388 p In ENGLISH and FRENCH Symposium held in Cesme/Izmir, Turkey, 22-25 May 1990
(AGARD-CP-473; ISBN-92-835-0578-6) Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Papers from the workshop are presented. The following guidance and control topics are addressed: Computer aided system design; Simulation technology for missile applications; Simulation technology for aircraft applications; Hardware in the loop simulation; Systems applications; and Pilot in loop simulations.

N91-15716# Aerospatiale, Marignane (France). Div. Helicopteres.
ALGORITHMS DEVELOPMENT METHODOLOGY FOR PERFORMANCE-OPTIMIZED MULTICYCLIC ROTOR COMMANDS
S. GERMANETTI and BERNARD J. GIMONET *In* AGARD, Computer Aided System Design and Simulation 14 p Aug. 1990 In FRENCH
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It is now necessary to use simulation between the conception of an idea and its realization in the domain of control laws. The attempts to measure classically simple models focus attention on the limited but important aspects of the many problems posed by control and the necessity of minimizing the volume of calculations. Simulations now used, so that the calculations are realistically creditable and flexible, are a more integral part of actual components, theory, and equipment. Wind tunnel tests and flight tests are not the ultimate phase of simulation. Numerical simulation allows a choice of complexity of landing phenomena. This data allows a change of analytic and verification tools thanks to the effectiveness of the available interactive means. The precise approach is given of simulation tools during development of control laws for optimization of helicopter performance. Transl. by E. R.

N91-15717# Bilkent Univ., Ankara (Turkey).
A DECENTRALIZED CONTROLLER FOR HIGHLY AUGMENTED AIRCRAFT
KONUR ALP UNYELIOGLU and A. BULENT OZGULER *In* AGARD, Computer Aided System Design and Simulation 10 p Aug. 1990
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The design is considered of a decentralized controller for the yaw pointing/lateral translation control of the Flight Propulsion Control Coupling (FPCC) aircraft, to increase the reliability of the

closed loop system with respect to absolute sensor failures. It is shown that better robustness results concerning absolute sensor failures with fixed zero output can be achieved by using decentralized dynamic compensator with high gain in the canard loop, at the expense of reduced phase and gain margins.
Author

N91-15718# Naples Univ. (Italy). Dipartimento di Informatica and Sistemistica.
PARAMETER SPACE DESIGN OF ROBUST FLIGHT CONTROL SYSTEMS
A. CAVALLO, G. DEMARIA, and L. VERDE (Italian Aerospace Research Center, Capua.) *In* AGARD, Computer Aided System Design and Simulation 13 p Aug. 1990

Generally, high performance requirements in terms of better efficiency (reduction in fuel consumption) and maneuverability, impose intrinsic instability on the aircraft. Then a Stability Augmentation System is required for its stabilization. Moreover, the aircraft must be safely controllable without any exceptional piloting skill. The requirements of stability and control are referred in literature as handling qualities. According to handling quality specifications, a feedback controller must be designed with robustness criteria with respect to flight conditions and sensor failure. A new design procedure of feedback controllers which allows the achievement of simultaneous stabilization, and provides some kind of fault tolerance with respect to sensor failure, are proposed. An application to the F4-E military aircraft is also presented.
Author

N91-15719# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Aircraft Div.
COMPUTER AIDED DESIGN AND SIMULATION OF THE AUTOMATIC APPROACH AND LANDING PHASE OF A COMBAT AIRCRAFT
F. D. LANGER *In* AGARD, Computer Aided System Design and Simulation 10 p Aug. 1990

Complex control systems like those used in modern aircraft can be efficiently designed and simulated with the aid of artificial intelligence tools. It is discussed how a symbolic manipulation program can be used to automate the steps which are necessary to design and simulate a control system. The landing phase of the MRCA Tornado is taken as an example. The automation of the development phase of a control system can reduce the workload of designers by doing repetitive, tedious, time consuming, and error prone tasks on the computer while letting the respective designers concentrate on more important issues. In the initial design phase, a six degree of freedom model is derived for the approach and landing mode of the aircraft configuration under consideration. The resulting nonlinear equations of motion are linearized around suitably spaced points of the flight trajectory. Next, control systems design methods are applied to the linearized set of equations to generate a control algorithm that satisfies prespecified goals. It is shown that a symbolic manipulation program can be employed as an integrated tool to derive the equations of motion, linearize them around a operating point, and produce a code for digital computer simulation.
Author

N91-15727# Universite Catholique de Louvain (Belgium).
SYMBOLIC GENERATION OF AIRCRAFT SIMULATION PROGRAMMES
P. MAES and P. Y. WILLEMS *In* AGARD, Computer Aided System Design and Simulation 9 p Aug. 1990

The main features are presented of a multipurpose computer program which provides aircraft equations of motion in symbolic form and can be used in various testing and simulation procedures. The entries of the program are compatible with ISO standards. Various possibilities are given to the users and, when appropriate, standard choices are suggested. Both kinematical and dynamical equations are derived. They permit the motion of a reference point fixed to the aircraft to be determined as well as the orientation of the system; they relate the variables which describe the motion to the controls and the interactions and perturbations acting on the system. The program is written in C language, but its output is a standard FORTRAN subroutine which can be used as such by the user. Among other things, this program can be used for simulation and design purposes for the vehicle and its control and navigation systems. It can also be used for air traffic control simulation and trajectory optimization; coupled with a numerical linearization subroutine, it also proves useful for stability analysis.
Author

N91-15728# Avions Marcel Dassault, Saint-Cloud (France). Div. Systemes Avioniques.
FORMAL TOOLS AND SIMULATION TOOLS: A COHERENT WORKSHOP
PATRICK SCHIRLE *In* AGARD, Computer Aided System Design and Simulation 12 p Aug. 1990 In FRENCH

Avionics systems today have become very complex and represent a large part of aircraft costs. The increasing cost over the last decade can be realized from the operational plans, technology, and methodology. Effective operations research and polyvalence carry an integration of many close functions, which are expressed by the optimization of physical and human resources (sensory fusion, human factors engineering, expert systems). For improvements in their efficiency, these methods rest on a number of information tools collected from coherent workshops. According to their place in the cycle of development, they represent the creative activities, verification, validation, or quality control. During some stages of development, the simulation allows verification to continue from the limited techniques of different specs. The simulation characteristics are from a different stage of development. The more upstream simulation allows hypothetical development to demonstrate their operability. Lastly, a simulation of system behavior is realized beginning with functional specs of the components. The methods and means are described which were used by the AMD-BA Society for the development of avionics systems from an industrial architecture viewpoint. The accent is placed on the different techniques and tools of simulation and their integration in a complete and coherent workshop.
Transl. by E.R.

N91-15729# Aeronautica Macchi S.p.A., Varese (Italy). Air Vehicle Technology Div.
AIRCRAFT CONTROL SYSTEM DESIGN, SYNTHESIS, ANALYSIS, AND SIMULATION TOOLS AT AERMACCHI
L. MANGIACASALE, L. V. CIOFFI, and C. A. BONATTI *In* AGARD, Computer Aided System Design and Simulation 10 p Aug. 1990

Three phases of an aircraft control system design are presented and discussed. From the preliminary synthetic design to the nonlinear simulation, the various steps proceed through the computational methods currently exploited at Aermacchi. Optimal and suboptimal methods are used in the first phase in order to get information about control strategies; accurate linear analysis is then performed with complex linear models for the continuous and sampled data design. The design is completed with three and six degrees of freedom nonlinear simulations in which the complete aircraft is simulated with an even more complex modelization.
Author

N91-15730# Electronic System G.m.b.H., Munich (Germany, F.R.).
COCKPIT MOCK UP (CMU): A DESIGN AND DEVELOPMENT TOOL
CHRISTOPH WEBER *In* AGARD, Computer Aided System Design and Simulation 9 p Aug. 1990

Designing a modern helicopter cockpit, ergonomics, operational, and technical aspects have to be considered. To ensure a low cost development schedule the Cockpit Mock-Up (CMU) is a flexible, inexpensive design and development tool for optimization of the Man Machine Interface (MMI). The ESG CMU, realized in close cooperation with the user, is a full size model cockpit of future helicopters such as NH 90 and PAH-2. The future user is integrated in the experimental closed loop simulation with the CMU. Author

N91-15731# Royal Aerospace Establishment, Bedford (England). Dept. of Flight Management.

COMPUTER-AIDED CONTROL LAW RESEARCH: FROM CONCEPT TO FLIGHT TEST

B. N. TOMLINSON, G. D. PADFIELD, and P. R. SMITH *In* AGARD, Computer Aided System Design and Simulation 15 p Aug. 1990

Active control technology (ACT) has changed the way aircraft can be designed and flown. The challenge for flight control research is, given the potential of ACT, to define what is required. In order to answer this question, a flyable implementation is needed, whether for a piloted flight simulator or for full scale flight. The need for implementation introduces issues of software design and management and possibly conflict with the needs of research. A domain is described for flight control law research being developed to provide a rigorous yet flexible framework. A comprehensive life cycle is defined for the evolution of flight control laws from concept via piloted simulation to flight test which, in its current form, has four major phases: conceptual design, engineering design, flight clearance, and flight tests. Conceptual design covers off-line simulation. Engineering design is the process of full control law design. Flight clearance consolidates results from earlier stages and achieves a verified implementation for the target flight control computer. Flight test evaluates the control system in full scale flight. A description of all these phases is presented. Control law life cycle examples are given. Author

N91-15732# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugmechanik.

REAL-TIME HARDWARE-IN-THE-LOOP SIMULATION FOR ATTAS AND ATTHES ADVANCED TECHNOLOGY FLIGHT TEST VEHICLES

PETER SAAGER *In* AGARD, Computer Aided System Design and Simulation 12 p Aug. 1990

Applications are given of the real time simulations used by DLR, and are followed by the presentation of the implemented hardware concept and some special aspects with regard to the simulation computers AD10 and AD100. This includes considerations of the analog and digital input/output handling with connected hardware in the loop (HIL). The advantage of higher simulation languages (CSSL based ADSIM, MPS10) as software tools for the development, modification, and implementation of complex and extensive software modules under real time simulation aspects is also considered. Based on this discussion is the description of problems with the correlation between the simulation frame time and the actual integration stepsize. Suitable integration algorithms and other supporting methods used within real time simulations to compute the dynamics of stiff systems are described. The presented helicopter's mainrotor simulation model serves as an example of the complexity of software modules, incorporated into the real time simulations. Finally, the actual method for the verification and validation of the simulation results and the principle diagnostic and test software application concept is explained. Author

N91-15735# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Flugmechanik.

A NEW APPROACH TO HARDWARE-IN-THE-LOOP SIMULATION (FALKE SHUTTLE)

C.-H. OERTEL, K. ALVERMANN, R. GANDERT, and B. GELHAAR *In* AGARD, Computer Aided System Design and Simulation 19 p Aug. 1990

System simulation is an important task in the development procedure of new and improved flight test vehicles. In addition to typical off-line and non-real time system simulations, special requirements for real time computation speed exists for flight simulators. Another application of real time simulation is the so called hardware in the loop (HIL) simulation, where real parts like new closed loop controllers or complete on-board systems are tested under realistic conditions. The progress in computer science shows a trend to distributed systems where multiple processors are running in parallel to improve the performance dramatically. At DLR a computer system, based on the TRANSPUTER was designed to achieve real time simulation capabilities for the FALKE Shuttle. This flight vehicle is a reduced size model of a reentry body which is used for a new aerodynamic flight test technique. The characteristics of the HIL simulation is presented along with an introduction to the FALKE flight test technique. Then an introduction to TRANSPUTERS is given along with a description of the hardware for simulation including all the interfaces to the FALKE. The simulation model is described and its mathematical formulation. Author

N91-15738# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

INTEGRATION OF A REALISTIC AIRLINE/AIRCREW/AIRCRAFT COMPONENT IN ATC SIMULATIONS

ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Computer Aided System Design and Simulation 10 p Aug. 1990

Present trends indicate that air traffic density will double over the next few years. The level of automation achieved in the aircraft itself allows a flight to be programmed and then conducted with little or no subsequent human intervention. In contrast, at the executive level, the air traffic authorities handle each flight as a succession of individual short segments and are not in a position to take much account of aircraft capabilities. The work done by EUROCONTROL is described with a view to integrating airline requirements, crew reactions, and aircraft capabilities in simulations aimed at assessing future air traffic handling procedures. Such procedures involve the 4-D guidance of aircraft which may possess the entire range of 2-D, 3-D, and 4-D navigation capabilities. Emphasis is placed on specific aspects such as (1) assessment of future 4-D ground/air guidance procedures under realistic conditions, and (2) assessment of the overall air traffic control loop. The solutions proposed in the two areas were tested and were presented to controllers, pilots, and pseudopilots. Author

N91-15739# Honeywell Advanced Technology Centre, Markham (Ontario).

NAVPACK: SIMULATION TOOLS FOR DESIGN OF HIGH PERFORMANCE INTEGRATED NAVIGATION SYSTEMS

JAN Z. ZYWIEL, JOHN S. A. HEPBURN, and BRUNO M. SCHERZINGER *In* AGARD, Computer Aided System Design and Simulation 6 p Aug. 1990

The NAVPACK Software Package for navigation systems simulation and analysis is described. The fundamental concept of NAVPACK is to create as modular a structure for the software as possible, with standard interfaces between separate programs and within individual programs. Therefore NAVPACK consists of distinct computer programs that perform individual simulation tasks. These programs are combined as needed at the operating system level

to perform the required processing. The NAVPACK software was successfully used for supporting a number of programs. It was used in the development of the Helicopter Integrated System (HINS). HINS requirements called for a high performance, robust, and fault tolerant integrated navigation system. Elements of NAVPACK were used for the development of a very high precision motion compensation system for high resolution, long range synthetic aperture radar. The package was also used in some work on a recently completed Marine Attitude Reference System (MARS), comprising an Inertial Navigation System (INS) capable of in motion alignment without aiding sensors. Author

N91-15741# Deutsche Airbus G.m.b.H., Hamburg (Germany, F.R.).
THE USE OF SYSTEM SIMULATION DURING THE DEFINITION PHASE OF THE PASSENGER TRANSPORT AIRCRAFT MPC75
DIETER DEY and AUGUST KROEGER *In* AGARD, Computer Aided System Design and Simulation 13 p Aug. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Some general remarks are presented concerning the tasks to be performed during the definition phase of a civil passenger aircraft and the importance is given of the use of simulation as a design tool. A more detailed differentiation of the terms systems and simulation is given with the emphasis on real time simulation. The present use of simulation in four areas is described: for systems engineering and know-how accumulation; for aircraft systems automation, monitoring, and handling in failure cases; for tests of programmed avionic boxes, specially the fly-by-wire system; and for flight simulation with and without pilot in the loop. Author

N91-15743# Boeing Co., Seattle, WA.
INTEGRATED TECHNOLOGY DEVELOPMENT LABORATORIES
DONALD E. DEWEY *In* AGARD, Computer Aided System Design and Simulation 7 p Aug. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

New integrated avionics technologies are capable of providing the performance improvements needed for current military aircraft. However, integrated laboratory facilities are needed to fully realize the potential of these technologies. The Boeing Co. has developed such a facility, a single laboratory capable of studying high integrated avionics systems from research through full scale development. Author

N91-15744*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION OF NAP-OF-EARTH FLIGHT IN HELICOPTERS
GREGORY W. CONDON *In* AGARD, Computer Aided System Design and Simulation 17 p Aug. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
CSCL 09/2

NASA-Ames in conjunction with U.S. Army has conducted extensive simulation investigations of rotorcraft in the nap-of-the-Earth (NOE) environment and has developed facility capabilities specifically designed for this flight regime. The experience gained to date in applying these facilities to the NOE flight regime are reported along with the results of specific experimental investigations conducted to understand the influence of both motion and visual scene on the fidelity of NOE simulation. Included are comparisons of results from concurrent piloted simulation and flight research investigations. The results of a recent simulation experiment to investigate simulator sickness in this flight regime is also discussed. Author

N91-15746# Test Squadron (6515th), Edwards AFB, CA.
THE DEVELOPMENT OF AVIONICS-INTENSIVE, MULTI-SENSOR COCKPITS: SIMULATION DOES NOT ALWAYS EQUAL SUCCESS
C. G. KILLBERG *In* AGARD, Computer Aided System Design and Simulation 8 p Aug. 1990
Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Simulation provides a critical foundation for the design and development of advanced aircraft. Present day wind tunnels and aerodynamic computer models are generally accurate to within a few percentages of actual performance. Simulators appear to provide a very accurate model of the environment for large transport category aircraft, which operate in comparatively benign conditions. Although the past decade has brought significant changes to the design of commercial airline cockpits, one may recall that for many years major commercial aircraft manufacturers tried in vain to modernize airline cockpits with significant improvements in instrument and display design. The use of simulation in the design and development of the cockpit man-machine interface for advanced multisensor aircraft is not always successful. Certainly simulation has been useful in the development of fighter/attack aircraft with high integrated cockpits. Some of the reasons for the failure of simulation to highlight some of these problems before a highly integrated fighter flys for the first time are examined. Author

N91-15751*# Computer Sciences Corp., Hampton, VA. Applied Technology Div.
ANALYTIC PATCH CONFIGURATION (APC) GATEWAY VERSION 1.0 USER'S GUIDE
BRADFORD D. BINGEL Dec. 1990 20 p
(Contract NAS1-19038)
(NASA-CR-187464; NAS 1.26:187464) Avail: NTIS HC/MF A03
CSCL 09/2

The Analytic Patch Configuration (APC) is an interactive software tool which translates aircraft configuration geometry files from one format into another. This initial release of the APC Gateway accommodates six formats: the four accepted APC formats (89f, 89fd, 89u, and 89ud), the PATRAN 2.x phase 1 neutral file format, and the Integrated Aerodynamic Analysis System (IAAS) General Geometry (GG) format. Written in ANSI FORTRAN 77 and completely self-contained, the APC Gateway is very portable and was already installed on CDC/NOS, VAX/VMS, SUN, SGI/IRIS, CONVEX, and GRAY hosts. Author

N91-15796# Sheffield Univ. (England). Dept. of Control Engineering.
SELECTION OF WEIGHTS IN OPTIMAL CONTROL
G. S. VIRK and J. M. TAHIR Jun. 1990 11 p
(RR-397; ETN-91-98525) Avail: NTIS HC/MF A03

A method to design the weighting matrices in the optimal control of an aircraft is presented. The method is equally suitable for any general multivariable application provided some prior knowledge is available to enable the rankings and the determination of the important terms. ESA

N91-16582# Midwest Research Inst., Golden, CO. Solar Energy Research Inst.
SMOOTHING AND SCALING AIRFOIL COORDINATES ON A PERSONAL COMPUTER
PETER K. C. TU and GEORGE N. SCOTT Dec. 1989 79 p
(Contract DE-AC02-83CH-10093)
(DE89-000878; SERI/TR-257-3372) Avail: NTIS HC/MF A05

A mainframe computer program written for smoothing and scaling coordinates was successfully adapted for use on personal computers (IBM PC or compatible microcomputers). The program was modified with a new format for input/output files, keyboard selection of plotting and printing options, and the ability to preview plots on a PC monitor before pen plotting. The new source code was then recompiled on a PC and used mainly for the purpose of supporting in-house aerodynamic research work. It was made compatible with other in-house codes. The system specifications for PCs are listed and the NASA Langley program and its theories used for smoothing and scaling airfoil coordinates are briefly described. A flow chart of the program and the input/output files are explained in detail. A step-by-step manual of executing the code on a PC and the results of sample runs are included. Also

included is an evaluation section of airfoil performance characteristics by using a low Reynolds number airfoil design and analysis computer code created to demonstrate the significance or any discrepancies as a result of the smoothing and scaling.
DOE

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A91-20614
PROPELLER NOISE MINIMIZATION WITHOUT THRUST LOSS DUE TO ASYMMETRIC BLADE DISTRIBUTION [PROPELLERLAERMMINDERUNG OHNE SCHUBVERLUST DURCH UNSYMMETRISCHE BLATTEILUNG]
WERNER DOBRZYNSKI (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1990, p. 29-33. In German.
Copyright
Measures which can be taken to minimize propeller noise caused by asymmetric blade distribution, without loss of thrust, are discussed. The theoretical optimization of angular separation and its relation to the minimization of noise is reviewed. Experimental results on various propellers are discussed. C.D.

A91-20747*# Kansas Univ., Lawrence.
PRESSURE-TIME HISTORY OF PYLON WAKE ON A PUSHER PROPELLER IN FLIGHT
SAEED FAROKHI (Kansas, University, Lawrence) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Nov.-Dec. 1990, p. 758-768. Previously cited in issue 21, p. 3401, Accession no. A89-49425. refs
(Contract NAG1-867)

A91-21255* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE PREDICTION OF STOVL NOISE - CURRENT SEMIEMPIRICAL METHODS AND COMPARISONS WITH JET NOISE DATA
PAUL T. SODERMAN (NASA, Ames Research Center, Moffett Field, CA) SAE, Aerospace Atlantic Meeting, Dayton, OH, Apr. 23-26, 1990. 31 p. refs
(SAE PAPER 901058) Copyright
The prediction of conventional or STOVL turbojet propulsion system-using aircraft noise is presently undertaken by means of a method incorporating empirical models for jet-mixing noise, engine core noise, and broadband shock noise. The free-jet noise is coupled with a novel empirical equation for ground-interaction noise generated by a vertically impinging jet, and supplemented with the out-of-ground-effect free-jet acoustic directivity pattern of a Harrier-type vectoring nozzle installation. This acoustic-prediction method yielded reasonable agreement with measured far-field Harrier noise during hover in and out of ground effect. Unlike small-scale studies of jet impingement on a hard surface, no tones were found in the present Harrier nozzle spectra. O.C.

A91-21511*# Lockheed Engineering and Sciences Co., Hampton, VA.
A STUDY OF LOUDNESS AS A METRIC FOR SONIC BOOM ACCEPTABILITY
KATHY E. NEEDLEMAN (Lockheed Engineering and Sciences Co., Hampton, VA), CHRISTINE M. DARDEN, and ROBERT J. MACK (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0496)
A parametric study of loudness levels with respect to weight, altitude, and Mach number for sonic boom signatures generated by two Mach 2.0 conceptual configurations is presented and compared with a similar study for nose shock overpressure. This paper discusses the relative importance of the two sonic boom metrics and the implications of the trends shown. Of the two configurations considered in this study, one was designed for optimum aerodynamic performance and the second was designed to produce a constrained overpressure sonic boom signature at cruise flight conditions. Results indicate that reductions in both loudness and overpressure level are possible when the configuration is shaped to produce a low boom signature. Results also prove that the loudness metric is a more reliable measure of the disturbance due to sonic booms than nose shock overpressure, because the overpressure does not include the sometimes significant effects of embedded shocks which are often present in mid-field low boom signatures. Author

A91-21545*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DIRECTIVITY AND PREDICTION OF LOW FREQUENCY ROTOR NOISE
C. L. BURLEY, M. A. MARCOLINI (NASA, Langley Research Center, Hampton, VA), H. E. JONES (NASA, Langley Research Center; U.S. Army, Aviation Systems Command, Hampton, VA), and W. R. SPLETTSTOESSER (DLR, Brunswick, Federal Republic of Germany) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 18 p. refs
(AIAA PAPER 91-0592) Copyright
Acoustic data obtained over a large horizontal plane under the model rotor and digitally filtered in order to determine the low-frequency content near the blade passage frequency is analyzed. Focus is placed on the directivity of low-frequency noise, and the changes in directivity as a function of the descent glide slope angle and advance ratio are presented and compared with predicted directivity results. The differences between the data and prediction are discussed for two observer positions, one below and on the rotor axis, and the other 60 degrees down from the horizontal. It is demonstrated that for the latter position, blade-vortex interaction noise is strong when it occurs, and the loading at the low frequencies is significantly affected during blade-vortex interactions. V.T.

A91-21546#
DEVELOPMENT OF A BOUNDARY LAYER NOISE PREDICTION CODE AND ITS APPLICATION TO ADVANCED PROPELLERS
PETER L. SPENCE (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(AIAA PAPER 91-0593) Copyright
A computer program is developed which models the refractive and scattering effects on acoustic pressure waves propagating through a boundary layer encompassing an aircraft's fuselage. The noise source is assumed known and generated by a propeller. The fuselage is represented by an infinitely long cylinder embedded in a longitudinal flow. A transfer function is derived in the paper by matching a numerical solution inside the boundary layer with an analytical solution outside the boundary layer. For a specified boundary layer velocity profile and thickness, the code calculates the acoustic pressure at the surface of the cylinder given the incident field at the top of the boundary layer. Numerical experiments illustrate the importance of describing the boundary layer velocity profile shape and thickness as accurately as possible. Results of the code are compared with flight test data measured during the Propfan Test Assessment (PTA) experiment. Comparisons of theoretical results with the measured data show good agreement. Author

A91-21547*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IN-FLIGHT SOURCE NOISE OF AN ADVANCED FULL-SCALE SINGLE-ROTATION PROPELLER
RICHARD P. WOODWARD and IRVIN J. LOFFLER (NASA, Lewis

Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 19 p. refs
(AIAA PAPER 91-0594) Copyright

Flight tests to define the far-field tone source at cruise conditions have been completed on the full-scale SR-7L advanced turboprop, which was installed on the left wing of a Gulfstream II aircraft. These measurements defined source levels for input into long-distance propagation models to predict en route noise. Inflight data were taken for seven test cases. The sideline directivities measured showed expected maximum levels near 105 deg from the propeller upstream axis. However, azimuthal directivities based on the maximum observed sideline tone levels showed highest levels below the aircraft. The tone level reduction associated with reductions in propeller tip speed is shown to be more significant in the horizontal plane than below the aircraft. Author

A91-21548#
ACOUSTIC POWER LEVEL COMPARISONS OF MODEL-SCALE COUNTERROTATING UNDUCTED FANS
B. A. JANARDAN and P. R. GLIEBE (GE Aircraft Engines, Cincinnati, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0595) Copyright

Sound power level and power spectra, computed from sound pressure measurements made in an anechoic facility, were used to quantify the noise characteristics of a model-scale counterrotating fan configuration. The model-scale sound power level data obtained with various blade numbers, blade pitch angles and simulated flight Mach numbers were correlated with performance results using statistical regression techniques. The data of all these configurations were determined to collapse well on the basis of shaft horsepower per blade, indicating that the fan noise is basically a function of loading on the blade. The usefulness of the model-scale sound power level in characterizing counterrotating fan noise data is demonstrated by relating it to scaled farfield acoustic metrics such as dBA and EPNL. Author

A91-22370#
THE INTERIM PREDICTION FOR AIRCRAFT NOISE
DIYI TANG, WENLAN LI, WEIYANG QIAO, and ZHENXIA LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 11, Aug. 1990, p. B334-B342. In Chinese, with abstract in English. refs

The acoustic emission from an aircraft during the flight is a dynamic process. The emitting acoustic power and received mean square acoustic pressure are the function of time. The paper deals with this problem as a quasi-steady one. The whole process is resolved into several elementary procedures, for example, the flight trajectory, the geometric relation between the noise sources and observers, the noise source characteristics,the air propagation, and ground effect. Two calculation examples are given, one for a long-range passenger aircraft with high bypass-ratio turbofan engine, another for a three-bladed propeller. The composition of aircraft noise, and its time record, frequency spectrum and directivity can be clearly described by these curves. Author

A91-22493#
EFFECT OF SLOTTING ON THE NOISE OF AN AXISYMMETRIC SUPERSONIC JET
ANJANEYULU KROTHAPALLI (Florida Agricultural and Mechanical University; Florida State University, Tallahassee), JAMES MCDANIEL (Virginia, University, Charlottesville), and DONALD BAGANOFF (Stanford University, CA) AIAA Journal (ISSN 0001-1452), vol. 28, Dec. 1990, p. 2136-2138. Previously cited in issue 17, p. 2685, Accession no. A89-41042. refs
Copyright

N91-15167# Thomson-CSF, Orsay (France).
SPECIAL OPTICAL FIBRES AND SENSORS FOR AERONAUTICS
JEAN-PIERRE LEPESANT and MARC TURPIN *In* AGARD, Advances in Components for Active and Passive Airborne Sensors 10 p Sep. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The primary motivations for using fiber optics for onboard communications, flight, and engine control in aircrafts, are immunity from electromagnetic interference and lightnings, lighter weight, smaller size, and a high degree of data formatting flexibility. The present status of the optical fiber fabrication technologies is presented along with some of the applications currently accessible for optical fibers in terms of inflight communications, navigation, and physical data collection and optical power transmission. Typical values are given of the characteristics made achievable by the evolution of the technologies. Author

N91-15842*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POTENTIAL REDUCTION OF EN ROUTE NOISE FROM AN ADVANCED TURBOPROP AIRCRAFT
JAMES H. DITTMAR Dec. 1990 19 p
(NASA-TM-103635; E-5809; NAS 1.15:103635) Avail: NTIS HC/MF A03 CSCL 20/1

When the en route noise of a representative aircraft powered by an eight-blade SR-7 propeller was previously calculated, the noise level was cited as a possible concern associated with the acceptance of advanced turboprop aircraft. Some potential methods for reducing the en route noise were then investigated and are reported. Source noise reductions from increasing the blade number and from operating at higher rotative speed to reach a local minimum noise point were investigated. Greater atmospheric attenuations for higher blade passing frequencies were also indicated. Potential en route noise reductions from these methods were calculated as 9.5 dB (6.5 dB(A)) for a 10-blade redesigned propeller and 15.5 dB (11 dB(A)) for a 12-blade redesigned propeller. Author

N91-15843 ESDU International Ltd., London (England).
AIRFRAME NOISE PREDICTION Abstract Only
Nov. 1990 30 p
(ESDU-90023; ISBN-0-85679-749-9; ISSN-0307-0115) Avail: ESDU

This Data Item 90023, an addition to the Noise Sub-series, provides the FORTRAN listing of a computer program for a semi-empirical method that calculates the far-field airframe aerodynamic noise generated by turbo-fan powered transport aircraft or gliders in one-third octave bands over a frequency range specified by the user. The overall sound pressure level is also output. The results apply for a still, lossless atmosphere; other ESDU methods may be used to correct for atmospheric attenuation, ground reflection, lateral attenuation, and wind and temperature gradients. The position of the aircraft relative to the observer is input in terms of the height at minimum range, and the elevation and azimuthal angles to the aircraft; if desired the user may obtain results over a range of those angles in 10 degree intervals. The method sums the contributions made by various components, results for which can also be output individually. The components are: the wind (conventional or delta), tailplane, fin, flaps (single/double slotted or triple slotted), leading-edge slats, and undercarriage legs and wheels (one/two wheel or four wheel units). The program requires only geometric data for each component (area and span in the case of lifting elements, flap deflection angle, and leg length and wheel diameter for the undercarriage). The program was validated for aircraft with take-off masses from 42,000 to 390,000 kg (92,000 to 860,000 lb) at airspeeds from 70 to 145 m/s (135 to 280 kn). Comparisons with available experimental data suggest a prediction rms accuracy of 1 dB at minimum range, rising to between 2 and 3 dB at 60 degrees to either side. ESDU

N91-16693*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LONG-RANGE VERTICAL PROPAGATION
WILLIAM L. WILLSHIRE, JR. and DONALD P. GARBER (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* 4th

International Symposium on Long-Range Sound Propagation p 127-132 Dec. 1990
Avail: NTIS HC/MF A12 CSCL 20/1

Development of the advanced turboprop has led to concerns about en route noise. Advanced turboprops generate low-frequency, periodic noise signatures at relatively high levels. As demonstrated in a flight test of NASA Lewis Research Center's Propfan Test Assessment (PTA) airplane in Alabama in October 1987, the noise of an advanced turboprop operating at cruise altitudes can be audible on the ground. The assessment of the en route noise issue is difficult due to the variability in received noise levels caused by atmospheric propagation and the uncertainty in predicting community response to the relatively low-level en route noise, as compared to noise associated with airport operations. The En Route Noise Test was designed to address the atmospheric propagation of advanced turboprop noise from cruise altitudes and consisted of measuring the noise of an advance turboprop at cruise in close proximity to the turboprop and on the ground. Measured and predicted ground noise levels are presented. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-22322
AIRCRAFT COST ESTIMATING - WEIGHT COMMONALITY AS A PREDICTOR
MARY MONICA SCOTT (U.S. Navy, Naval Air Systems Command, Washington, VA) SAWE, Annual International Conference, 48th, Alexandria, VA, May 22-24, 1989. 21 p.
(SAWE PAPER 1909) Copyright

The Naval Air Systems Command has developed a Weight Commonality Statement (WCS) for defining common and peculiar weights, with a view to estimating the costs of derivative aircraft. It is in principle possible to identify points were peculiar weight, defined as weight that is added or reduced, has an impact on design and production factors. Attention is presently given to the initial assumptions for, and preliminary treatment of, the weight data used in the cost-estimating relationship, as well as to two illustrative WCS applications: (1) estimates of nonrecurring tooling requirements, and (2) projections of recurring manufacturing costs. O.C.

N91-15928# Wichita State Univ., KS. National Inst. for Aviation Research.
INTERNATIONAL AIRCRAFT OPERATOR INFORMATION SYSTEM, PHASE 2 Program Plan
JOHN J. HUTCHINSON and BARBARA K. SMITH Dec. 1990 14 p
(Contract DTFA03-89-C-00057)
(NIAR-90-31; DOT/FAA/CT-90) Avail: NTIS HC/MF A03

This program plan outlines the development of an International Aircraft Operator Information System as described in the Master Requirements and Implementation Plan. The program plan outlines the process of data development, prototype development, prototype testing, prototype operation, and system operation. This information system will assist the Federal Aviation Administration with the distribution of aircraft safety information to aircraft operators, and others, in a cost effective manner using an automated, menu driven system. Author

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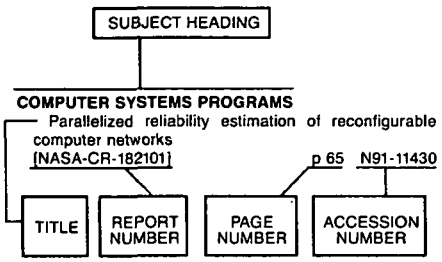
GENERAL

N91-15975*# National Aeronautics and Space Administration, Washington, DC.
ENGINES AND INNOVATION: LEWIS LABORATORY AND AMERICAN PROPULSION TECHNOLOGY
VIRGINIA PARKER DAWSON 1991 277 p
(NASA-SP-4306; NAS 1.21:4306; LC-90-20747) Avail: NTIS HC/MF A13 CSCL 05/4

This book is an institutional history of the NASA Lewis Research Center, located in Cleveland, Ohio, from 1940, when Congress authorized funding for a third laboratory for the National Advisory Committee for Aeronautics, through the 1980s. The history of the laboratory is discussed in relation to the development of American propulsion technology, with particular focus on the transition in the 1940s from the use of piston engines in airplanes to jet propulsion and that from air-breathing engines to rocket technology when the National Aeronautics and Space Administration was established in 1958. The personalities and research philosophies of the people who shaped the history of the laboratory are discussed, as is the relationship of Lewis Research Center to the Case Institute of Technology. Author

Typical Subject Index Listing



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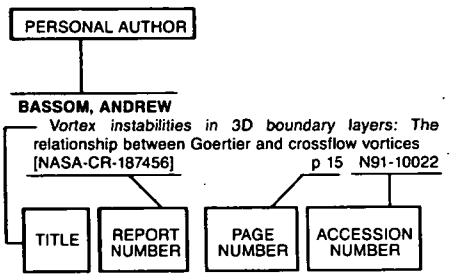

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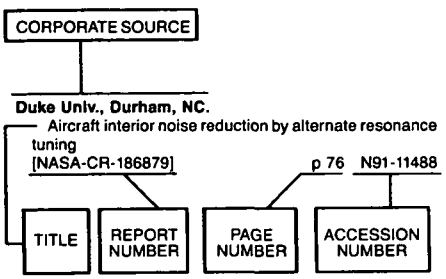

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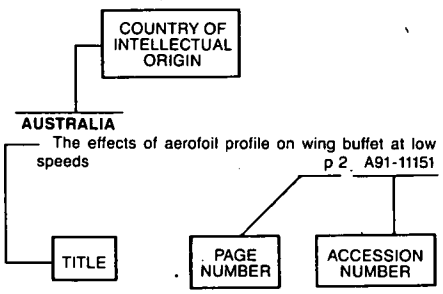

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AUSTRALIA

Turbulent shear flow over surface mounted obstacles p 252 A91-21057

Parametric study on thrust production in the two dimensional scramjet [AIAA PAPER 91-0227] p 298 A91-21417

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Identification of time delays in flight measurements p 327 A91-22953

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B

BELGIUM

Symbolic generation of aircraft simulation programmes p 328 N91-15727

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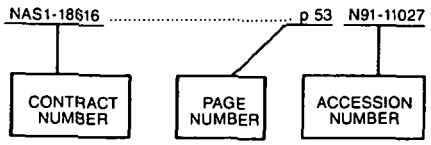

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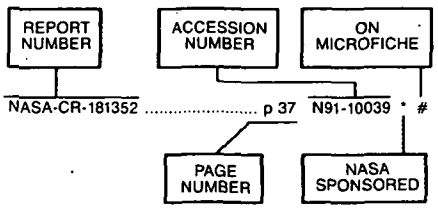

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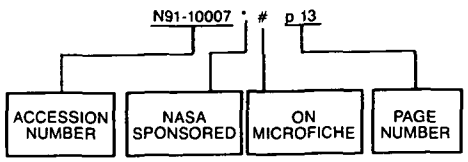

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